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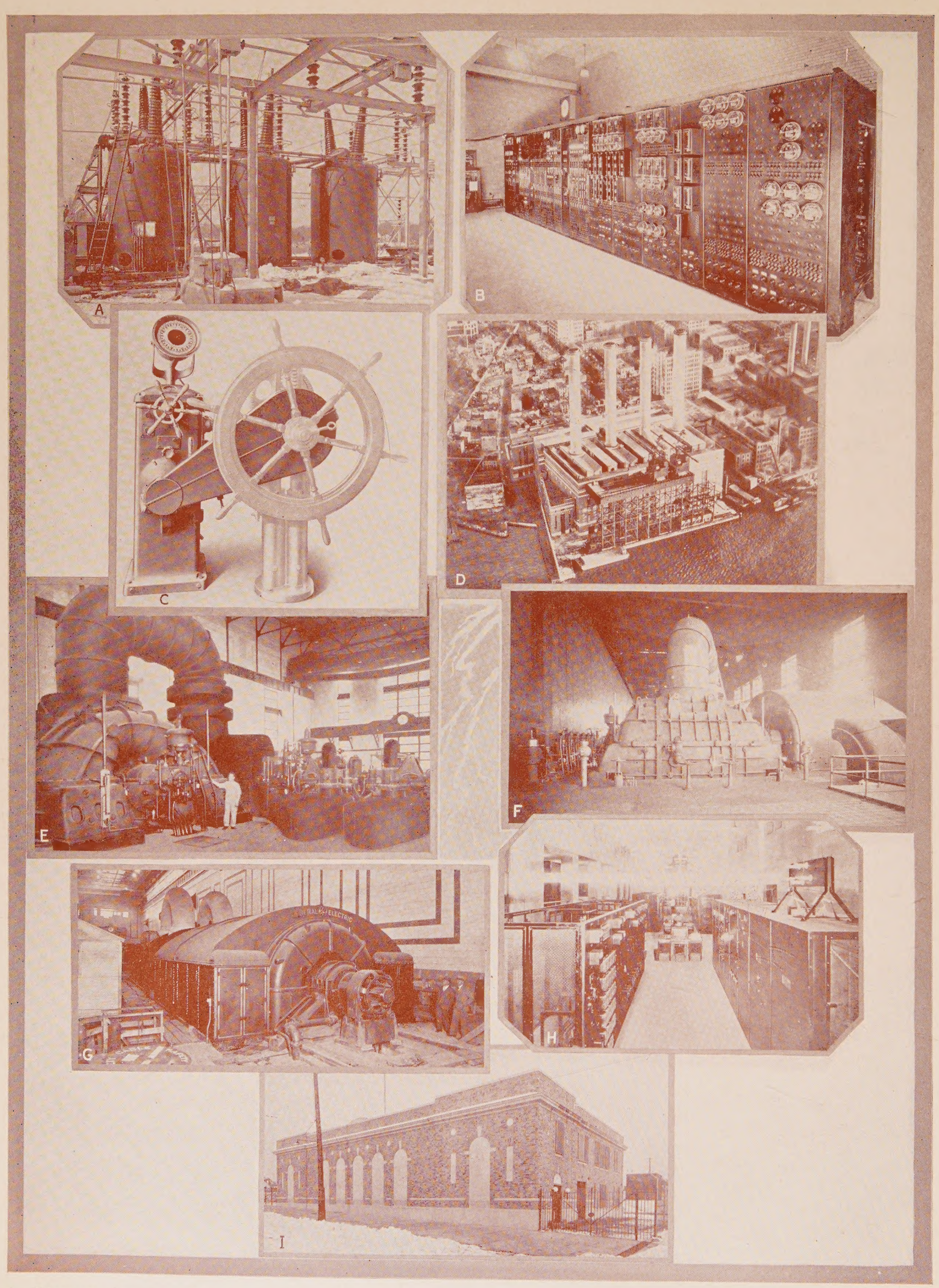
WINTER CONVENTION, NEW YORK, JANUARY, 27-31




A. Roseland Switching Station 220-Kw. Circuit Breaker
B. Supervisory Control Panel at W. 238th St. Station, New York Edison Co.
C. Sperry Gyro Pilot "Metal Mike"
D. Hudson Ave. Station, Brooklyn Edison Co.
*—Photo by Air Map Corporation of America*

E. Hudson Ave. Station, 110,000-Kw. Generator
F. Hell Gate Station, 160,000-Kw. Turbo Generator
G. N. Y. Edison Co., 160,000-Kw. Generator, East River Station
H. Interior of Short Wave Transoceanic Telephone Transmitting Station
I. Laconia Ave. Station, Bronx Gas & Electric Co.

# JOURNAL of the A. I. E. E.

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street, New York

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# MEETINGS

of the

## American Institute of Electrical Engineers

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WINTER CONVENTION, New York, N. Y., January 27-31, 1930

NORTH EASTERN DISTRICT MEETING No. 1, Springfield, Mass., May 7-10, 1930

SUMMER CONVENTION, Toronto, Ontario, Canada, June 23-27, 1930

PACIFIC COAST CONVENTION, Portland, Oregon, September 2-5, 1930

MIDDLE EASTERN DISTRICT MEETING, No. 2, Philadelphia, Pa., October 13-15, 1930

SOUTHERN DISTRICT MEETING, No. 4, Louisville, Kentucky, November 19-22, 1930

### MEETINGS OF OTHER SOCIETIES

American Engineering Council, Washington, January 9-11, 1930 (L. W. Wallace, 26 Jackson Place, Washington, D. C.)

Conference of Electrical Leagues—Westinghouse Lighting Institution, New York, N. Y., January 13-16. Society for Electrical Development, 420 Lexington Avenue, New York, N.Y.

National Electric Light Association
North Central Division, Engineering Section, Nicollet Hotel, Minneapolis, Feb. 24-25. (J. W. Lapham, 803 Plymouth Building, Minneapolis, Minn.)

# JOURNAL OF THE A. I. E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

*The Institute is not responsible for the statements and opinions given in the papers and discussions published herein. These are the views of individuals to whom they are credited and are not binding on the membership as a whole.*

Vol. XLIX JANUARY, 1930 Number 1

*A Message From the President.*

## The New Year and Problems of the Institute

THE beginning of a new year is a favorite and an appropriate time to consider problems of the present and of the future. What have we to think about at this time in connection with the Institute? Among many items needing consideration, the following may be briefly stated.

The conditions under which student members of the Institute may be transferred to associate membership has received consideration at the hands of both the Denver and the Swampscott Section and Branch Delegates Conferences and by the Board of Directors. A committee, authorized by the Board of Directors, was appointed last August and, after effective work, now has a report to go before the Board at its next meeting with a view to having greatly improved conditions in effect next year.

The long standing and complicated problem of standardization as affecting, or as affected by, the practise and policy of the American Institute of Electrical Engineers is evolving to a point where there appears to be prospect of progress and final solution. Much thought and effort is being put upon this question by the Standards Committee, the Board of Directors, and others. This comes before the Board of Directors at an early date for further consideration and possible action.

It appears that the time has now come for active consideration of a plan to bring to the Sections of any District, or small group of Districts, speakers of distinction in accordance with a schedule as mentioned in the September issue of the JOURNAL.* This plan has aroused cordial interest in many Sections of the Institute where it has been discussed as likely to be of much benefit in stimulating Section interest and activity. Details of such a plan are being formulated for consideration by the Board of Directors.

What should be the policy and activity of the Institute in a fundamental question involved in the broad problem of the "status of the engineer?" Shall we follow the methods adopted by the medical profession in improving their own status or some method better adapted to the present conditions of the engineering profession? This is a question of far reaching importance and requiring consideration at the present time, but needing deliberate thought and development over a long period. Much work on this question has been done by the Committee on Education of the Institute, much by the Society for the Promotion of Engineering Education and the Carnegie Foundation, much by other organizations, committees, and individuals. *Has there been enough done by the cooperation of the several engineering societies standing back of the educational institutions and with the cooperation of the applied engineering industry as a whole?*

Harold B. Smith

*President*

*See item d, page 659.

## Some Leaders of the A. I. E. E.

Giuseppe Faccioli, Associate Manager and Works Engineer for the General Electric Company of Pittsfield, Mass., Manager of the Institute 1918-22, and one of its Vice-Presidents 1922-24, was born in Rome, Italy, in 1877. In 1899 he was graduated with high honors from the Institute of Technology, Milan, Italy, as a mechanical and electrical engineer. He spent the first years of his career in designing a-c. machinery.

In his early professional work he followed with keen interest the development of the electrical industry in the United States, and ultimately felt impelled to come to America to obtain a personal contact with what was taking place. He was 25 years of age at the time of his arrival. He first sought and obtained a position with the New York Edison Company, and having acquired valuable experience in the laboratories of that organization, he decided that he should know something about transportational work in a large metropolitan system. He therefore secured a position with the Interborough Rapid Transit Company of New York.

He was about to return to Italy but considered that his experience would be incomplete unless he knew more about the work of the larger electrical manufacturing organizations. His expectations, however, were to devote only a few months to this work. He found just such opportunity open to him in the Engineering Department of the Crocker-Wheeler Company, and in 1904 he took up work with them as a designing engineer. While with them and working on the design of a new induction alternator for William Stanley, he did what Mr. Stanley considered pioneer work in forecasting by method of calculation the results which would be obtained on a new type of alternator. This feat so much impressed Mr. Stanley that he persuaded Mr. Faccioli to come to Great Barrington, Massachusetts, as his Chief Assistant. As a result of this move, what was intended for a short visit to America became a permanent stay.

In 1906 the Stanley Laboratories became a part of the General Electric Organization, and in 1908 Mr. Faccioli was transferred to the Engineering Department of the Pittsfield Works of the General Electric Company. In 1911 he was appointed Assistant Chief Engineer of the Transformer Department, and in 1914 became Work's Engineer. July, 1927 he was appointed Associate Manager and Work's Engineer of the Pittsfield Works, which is the position he now holds.

Early in his work in this country he became interested in the affairs of the A. I. E. E. For many years he has not only maintained a keen interest in the work of the Institute, but has been, and is, an indefatigable worker in its behalf. After having been a member year after year of some of the most important committees of the Institute, and having served four years on the Board of Directors as Manager, he was elected in 1922 as Vice-President for District No. 1. While Vice-President, the inspirational leadership of Mr. Faccioli resulted in the establishment of Regional Meetings and Regional Prizes in District No. 1. These activities have since been placed on a national Institute basis and have been adopted by the other districts.

While Mr. Faccioli's early experience was centered to a considerable extent in the design and development of a-c. machinery, he foresaw and interested himself in the possibilities of high-tension transmission and the problems which presented themselves for solution.

Beginning with his early and pioneer work on corona on the systems of Eastern Colorado and on high-tension switching and line oscillations on the system of the Great Western Power Company, he has for the last fifteen years given a large portion of his time to the study of high-tension transmission and the development of the apparatus which makes such transmissions a possibility. This work later extended to development of high-tension transformers, lightning arresters and protective equipment.

While not a prolific writer, Mr. Faccioli is the author of many papers on engineering subjects and are read with great interest by the engineering profession.

Notwithstanding the effective and brilliant work which Mr. Faccioli has done in following his chosen career, it is not by this alone that he is best known and admired by his close associates or casual acquaintances. It is rather by his delightful personality—his keen interest in, and sympathetic appreciation of the problems of others and a manifest desire on his part to simplify and advance the art of engineering in the electrical world.

---

Search for the newest and most spectacular effects in lighting to be placed in contrast to the comparatively primitive methods of illumination in 1833 is being made by a group of the foremost illuminating engineers in the country under the direction of W. D'Arcy Ryan, head of the Illuminating Engineering Laboratories at Schenectady, New York.

The illuminating Engineering exhibit in the Hall of Science at the Chicago Century of Progress celebration in 1933 will be based on recommendations made by Mr. Ryan and his collaborators who are acting under the auspices of the National Research Council's Science Advisory Committee which has been asked to formulate a science theme for the Chicago fair.

Mr. Ryan's group will ask for three acres of floor space in the Hall of Science for the illuminating exhibit. Though the period between 1833 and 1933 will be emphasized in developing ideas, a broad historical background is contemplated going back to the days when primitive man lighted up his cave with a torch made of fagots.

In addition to lighting effects, the illuminating exhibit, it is expected, will comprise mural paintings, groups of sculpture, models, designs and reproductions of apparatus used in the production of light.

# Operating Transformers by Temperature

BY W. M. DANN[1]

Fellow, A. I. E. E.

***Synopsis.***—*This paper discusses a proposal, sponsored by the Transformer Subcommittee of the Committee on Electrical Machinery, which is intended to serve as a guide in operating transformers by temperature rather than in accordance with their nameplate ratings.*

*There is a real difference between "rating standards" and "recommendations for operation;" one simply specifies the measure of a machine under a definite set of conditions and the other constitutes a guide for loading under the varying conditions of actual service. With this difference in mind, a departure from the practise of the Institute up to this time is suggested; namely, that these operating recommendations be placed in an appendix of the Standards and considered not as rating standards but purely as a guide in loading transformers which have been designed to meet the Standards of Rating.*

*One of the first things that had to be done in framing these recommendations was to settle the maximum safe limiting temperature of the windings for operation in actual service. The aim in making this selection was to provide for reasonable deterioration of the insulation and therefore a reasonably long life for the transformer. For reasons disclosed in this paper, a limiting temperature of 95 deg. cent. was adopted. This limit is 10 deg. below that used in the Standards for Rating.*

*These are the high points of the proposal. But opinion on these matters seems to be rather divided throughout the industry, and the purpose of this paper is to bring them to the attention of all members of the Institute.*

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THE A. I. E. E. Standards for Transformers have served a useful purpose in setting up recognized specifications for ratings and acceptance tests: they have brought about a uniform rating practise which makes it possible for the manufacturer more nearly to standardize his product and for the purchaser to know what he is buying and compare bids intelligently.

For rating purposes, the Standards recognize a maximum hottest-spot temperature in the windings of 105 deg. cent. set a number of years ago at what was thought to be the limit of temperature to which fibrous insulation should be subjected continuously for reasonable deterioration. The elements of temperature represented by these Rating Standards are as follows:

| | Air blast and oil-insulated self-cooling | Oil-insulated water-cooled |
|---|---|---|
| Ambient temperature | 40 deg. cent. | 25 deg. cent. |
| Temperature rise | 55 | 55 |
| Limiting observable temperature | 95 | 80 |
| Margin for hot spots | 10 | 10 |
| Maximum limiting temperature | 105 | *90 |

*Since water-cooled transformers are dependent upon artificial means of cooling that might be interrupted and involve a cooling system that might deteriorate on account of scale or deposit from water containing impurities, the Standards for Rating provide for them an extra margin of 15 deg. cent.; this results in a uniform standard temperature rise of 55 deg. cent. for both water-cooled and self-cooled transformers.

It is obvious that if the ambient temperature in actual operation is lower than that used in the rating scheme, the hottest spot temperatures of the windings in a transformer meeting the Rating Standards will be less than the maximum limiting temperature of the scheme. If the limiting temperature of 105 deg. cent. is actually a safe maximum temperature for continuous operation, then it follows that the load may be increased above the nameplate rating to the point where the limiting temperature of 105 deg. cent. is reached.

It has been recognized for a long time that extra output is available when the ambient temperature is low. But no simple and usable rules have ever been established which would give the operator of a transformer a chance to make use of this extra output to suit his own conditions of ambient temperature. For some time there has been a strong feeling that an authoritative set of rules defining a reasonable practise of this kind ought to be available.

The Transformer Subcommittee[2] of the Committee on Electrical Machinery recently spent over two years in preparing a guide for the loading of transformers in actual service, with the hope of formulating a simple set of rules which would allow this latent capacity to be used. These rules were published tentatively in the August 1928 issue of the A. I. E. E. JOURNAL, and they also appear in the Report on Standards for Transformers, Induction Regulators and Reactors dated August 1928. They are reproduced here in order to make direct and connected references to them.

*Appendix.*—Recommendations for the Operation of Transformers, Induction Regulators, and Reactors.

"13-600 *Limiting Observable Temperature of Oil*—

The oil in which apparatus is permanently immersed should under no circumstances have a temperature, observable by thermometer, in excess of 90 deg. cent.

"13-601 *Operation at Rated Load*—

"Apparatus conforming with the Standards for Rating is suitable for carrying rated load continuously provided that the temperature of the cooling medium

1. Westinghouse Elec. & Mfg. Co., Sharon, Pa.

*Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 27-31, 1930.*

2. Members of the Subcommittee completing the work were: W. H. Cooney, J. B. Gibbs, J. Allen Johnson, A. H. Kehoe, H. C. Louis, V. M. Montsinger, L. C. Nichols, and W. M. Dann.

does not exceed 40 deg. cent. for air or 25 deg. cent. for water.

"13-602 *Operation with Cooling Air and Water Exceeding 40 Deg. Cent. and 25 Deg. Cent. Respectively*—

"For apparatus conforming with the Standards for Rating, the load should be reduced 2 per cent below the rated load for each degree that the temperature of the cooling air exceeds 40 deg. cent. or that the temperature of the cooling water exceeds 25 deg. cent. However, the use of apparatus in cooling air exceeding 50 deg. cent. or in cooling water exceeding 35 deg. cent. shall be considered as special.

"13-603 *Operation at Loads Greater than the Rated Load**—

(a) Apparatus Not Equipped with a Winding-Temperature Indicator:—Apparatus not equipped with a winding-temperature indicator may be loaded continuously 1 per cent above rated load for each degree centigrade that the temperature of the cooling medium is below 30 deg. cent. for air or 25 deg. cent. for water.

"Thus, for example, when the temperature of the cooling medium is 0 deg. cent., the permissible continuous load is 130 per cent of rated load for air-cooled apparatus and 125 per cent of rated load for water-cooled apparatus.

"Loads greater than 130 per cent of rated load for air-cooled apparatus or 125 per cent of rated load for water-cooled apparatus shall not be applied under any conditions even though the temperature of the cooling medium be lower than 0 deg. cent.

"(b) Apparatus Equipped with a Winding-Temperature Indicator: Apparatus equipped with a winding-temperature indicator may be loaded continuously in excess of rated load provided the indicated winding-temperature does not exceed the following limits:

"For indicators marked in terms of

Hottest spot Temperature...........95 deg. cent.

Embedded Detector Temperature....90 deg. cent.

Resistance Method Temperature.....85 deg. cent.

"(c) Oil Temperatures: Oil temperature alone is an inadequate criterion of the winding temperature because of the increased temperature drop through the insulation at low temperatures of the cooling medium and of the time lag between the winding and oil temperatures. Loading apparatus on the basis of oil temperature alone as a guide is not recommended."

*Since the operation of apparatus at loads greater than rated load increases the probability of maintaining the limiting temperature for a greater portion of the time, and because the life of insulation is a function of both its temperature and the time of subjection to that temperature, the operating temperature of the winding should be limited to a lower value than for operation at rated load.

Also, under these conditions, the temperature difference between the observable temperature and the hottest-spot temperature increases.

For these reasons, the limits specified in Para. 13-603, which are 10 deg. cent. lower than the highest observable temperature recognized for apparatus operated at rated load, have been agreed upon for purposes of standardization.

## Rating Standards and Recommendations for Operation

There is a distinct difference between rating standards and authorized rules for operation. Standards for Rating simply prescribe a measure of a machine under fixed and definite conditions. These conditions may not, in fact they cannot, represent actual operating practise, because in real service, load demands are usually variable and ambient temperatures are not fixed, but rather are changing from hour to hour. Rules for operation should take these changing conditions into account. Therefore, while the two sets of rules are not unrelated, they cannot be one and the same thing. For these reasons, the proposed recommendations for loading transformers by temperature are not to be looked upon as rating standards. They are not intended to be used in the purchase of transformers or to establish performance which is subject to guarantee and demonstration by test. They are offered simply as recommendations for guidance in the safe operation of transformers in service under various conditions of ambient temperature.

It has been planned that if these recommendations are to be sponsored by the Institute, they should be separate and apart from the rules devoted to Rating Standards, and they have been tentatively placed in an appendix to Section 13. In the discussion following the preliminary publication, the opinion has been rather strongly expressed that service recommendations of this kind should not be included in the Institute Standards even when definitely set apart from the Rating Standards. This opinion is based upon the principle that the scope of the Institute Standards is limited to the defining of Rating Standards. At the same time there is an opinion from other quarters that the Institute should go further than simply to set up arbitrary rating standards; that it is proper for it to sponsor and authorize recommendations for the actual operation of machines that are designed in accordance with the Rating Standards. In the face of these conflicting opinions it becomes a matter that the Institute as a whole should become interested in. The broader question developed requires serious consideration because of the possibility of extending the principle to other applications.

The proposed loading recommendations for transformers are based upon engineering data, and actual loading experience has been taken into account as far as it has been possible. The purpose of this paper is to discuss and interpret the recommendations without going into detail as to the data upon which they are based. These data are well illustrated in a companion paper on the subject being presented at this time by V. M. Montsinger.

### Limit of Safe Operating Temperature

The first thing that must be settled when considering recommendations for loading transformers by temperature is the maximum safe operating temperature limit, because temperature affects the rate of deterioration of the insulation, and, barring accidents, it is the thing that determines the useful life of a transformer. In trying to decide this question, one naturally turns to previous experience for guidance. Heretofore the useful life of transformers, speaking generally, has been of satisfactory length, and we have not been hampered by rapid deterioration of insulation. However, operating experience has been confined practically to loads which have not exceeded nameplate ratings, and average loadings have been even less. Couple these considerations with the fact that ambient temperatures are usually less than those of the Rating Standards, and it is found that experience has in general been limited to moderate temperatures, temperatures that are considerably lower than the limit of 105 deg. cent. which was adopted for rating purposes. As a result, no one knows definitely from broad general operating experience just where the maximum limit of temperature for continuous loading should be set to maintain reasonably long useful life.

A higher level of operating temperatures will be the natural result of loading transformers by temperature, because in general greater loads will be carried. The copper losses increase with the square of the increase of load current, and the rise of temperature of the windings increases almost as rapidly. New and unknown factors affecting experience are introduced, and these factors have an influence upon the rate of deterioration of the insulation.

Taking all of these things into account, it was determined that conservatism should be the keynote of these loading recommendations. In keeping with this decision, a maximum limit of 95 deg. cent. for the hottest spot temperature was adopted for operation instead of the 105 deg. limit used for rating purposes. When more experience with the higher level of operating temperature is accumulated, it will be possible to set the limit with greater confidence. It is not impossible that eventually a limit of 105 deg. cent. for actual operation may be found to result in reasonably long useful life.

The difference between the temperature limit for rating and this proposed limit for operation has caused considerable discussion since the preliminary publication of the loading recommendations. It has been said that this difference is illogical; that when one buys a transformer meeting the Standards for Rating he is entitled to operate it up to the limit of 105 deg. cent. continuously because that is what he has bought and paid for. If the point has been successfully made in the preceding discussion that there is a clear-cut distinction between standards for rating, which simply set a measure for uniformity in design, and recommendations for operation, which are intended to serve as a guide in actual operation with all its varying conditions, perhaps it will be conceded that a greater margin of safety is justified in the operating recommendtions until experience has demonstrated whether or not it is needed.

### Operation at Loads Greater than the Rated Load

There are two general classes into which transformers may be divided when considering operation by temperature above the rated load: first, that large class of units that either have no temperature indicators or are equipped with indicators that simply show the temperature of the oil; second, the rapidly increasing class of units that are equipped with winding temperature indicators, giving an indication in some degree of the approximate temperature of the windings.

For the first class of transformers, paragraph 13-603 (a) provides a simple rule which allows one to determine what load may be carried with any prevailing condition of ambient temperature. Within the limits of the recommendations, the "1 per cent rule" conforms quite reasonably in its results with the adopted maximum limit of 95 deg. cent.

No loading above the rated load is recommended for air cooled apparatus unless the ambient temperature is below 30 deg. cent., and this may need explanation. If continuous loading above the nameplate rating were to be recommended between ambient temperatures of 30 deg. and 40 deg. cent., hottest spot temperatures of the windings might exceed the limit of 95 deg. cent. adopted for operation, and the conservatism of the loading recommendations would not be followed out. Air temperatures in the United States, speaking generally, are not as high as 40 deg. cent. They usually do not exceed 20 deg. or 25 deg. cent. except in the warmest periods. Most of the operating experience has therefore been with temperatures of a moderate order. If loads were to be increased for all ambient temperatures below 40 deg. cent., in accordance with the "1 per cent rule," it would mean that most of the self cooling transformers now in service could immediately be loaded well above their nameplate ratings. Following out the principle of conservatism, it was thought better to avoid such a wholesale overloading until more operating experience in loading by temperature has been accumulated.

For ambient temperatures below 0 deg. cent., there is of course some additional overloading possible within the adopted limiting temperature. However, for conservation, overloading is limited in the recommendations to that prescribed for 0 deg. ambient.

Paragraph 13-603 (b) describes the permissible loading above the nameplate rating for the second general class of transformer apparatus, *i. e.*, for apparatus equipped with a winding-temperature indicator. The principle of limiting hottest spot temperatures to the adopted figure of 95 deg. cent. is carried out in this

paragraph, but the actual limiting temperature depends upon the temperature that the instrument really measures, due to its construction and application.

Three different types of winding-temperature indicators are used for power transformers at the present time, each type indicating a different degree of winding temperature. For that reason, three different limiting temperatures were established, each one relating definitely to the kind of instrument used. The following short descriptions will show why these indicated temperature limits are different:

*95-deg. Limit.*—One manufacturer provides a winding-temperature indicator marked in terms of the hottest spot temperature. It includes in its calibration the 10 deg. margin above the average winding temperature at full load which the A. I. E. E. Standards recognize as the conventional allowance for hot spots. The limiting temperature for this type of indicator is set at 95 deg. cent.

*90-Deg. Limit*—Another manufacturer provides a winding-temperature indicator which uses a long strip of high resistance metal wound in with the turns of a coil, usually the top coil of a stack. This strip of metal forms one of the arms of a Wheatstone bridge. It gets its temperature very largely through the insulation of the conductor with which it is in contact. It measures something between the hottest spot temperature and the average temperature of the windings by the resistance method.

The limiting temperature for this type of winding-temperature indicator is set at 90 deg. cent. because parts of the copper in the windings will be somewhat higher in temperature than that indicated.

*85-Deg. Limit*—A third manufacturer provides an indicator having a heating coil which adds to the oil temperature an increment representing the difference between the average winding temperature and the oil. It indicates the average temperature of the winding as it would be measured by the resistance method without any allowance for hot spots.

The limiting temperature for this type of indicator is accordingly set at 85 deg. cent.

Transformers may be safely loaded up to these limiting indicated temperatures regardless of what the ambient temperature may be.

## Operation at Rated Load

Paragraph 13-601 provides that a transformer conforming with the Standards for Rating is suitable for continuous operation at rated load if the ambient temperature does not exceed 40 deg. cent. for air or 25 deg. cent. for water. Assuming the conventional allowance of 10 deg. for hot spots, this statement as it applies to a self-cooling transformer is not consistent with the adopted hottest spot temperature limit of 95 deg. cent. for operation.

However, something may be said in defense of this inconsistency. For loads not exceeding rated load, the actual difference between the hottest spot temperature of the winding and the temperature of the oil (which increases very rapidly with overloads) is usually less than contemplated by the Rating Standards and is not a matter of concern. Also, the operation of standard transformers at rated loads has been satisfactory in the past for the conditions of actual service and bids fair to continue to be satisfactory in the future.

An inconsistency of some kind is inevitable when the limiting temperatures for rating and for operation are different, and for the reasons given it was thought better to be consistent with the Standards for Rating in the case of rated load operation rather than with the adopted operating limit of 95 deg. cent.

## Operations with Ambient Temperatures Above Those of the Rating Standards

Paragraph 13-602 was designed to include the unusual cases where ambient temperatures exceed those set by the Rating Standards. Since the 1 per cent rule is an approximation which gives conservative results for overloads as recommended for low ambients but not for partial loadings at high ambients, it was necessary to make a reduction of 2 per cent in load for each degree by which the ambient temperature exceeds the standard ambients in order to keep within the 95 deg. operating limit.

## Conclusions

The principle function of the Institute as it has been understood up to the present time, is to provide Standards for Rating. The proposal that Recommendations for Operation be included in the Standards as an appendix is an innovation. It is in fact a proposal affecting the policy of the Institution, one which might be far-reaching in its application, if it were adopted. A strong feeling has developed since preliminary publication of the proposal, that the Institute should continue to devote its attention to rating standards and that recommendations for actual operation of apparatus should be sponsored by some other organization.

The selection of a limit of temperature for operation which is lower than the limit recognized for rating purposes may be considered open to question. However, there is ample justification for conservatism in starting a new practise which may involve the possibility of shortened life of apparatus, and it is probably wise to be content with the very reasonable increase of capacity which the lower temperature limit provides until it may be demonstrated that a higher limit is warranted.

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More than 190 pieces of historical electrical apparatus have been presented to Henry Ford by Columbia University for display in Edisonia, the museum Mr. Ford is founding at Dearborn, Mich., in honor of Thomas Edison, according to an announcement by Professor Walter I. Slichter of the Department of Electrical Engineering. The gift was authorized by the Department of Engineering after Mr. Ford had inspected the collection of electrical apparatus.

# Quiet Induction Motors*

BY L. E. HILDEBRAND[1]
Member, A. I. E. E.

*Synopsis.—Magnetic noise in induction motors is caused by the vibration of magnetic parts produced by the varying forces associated with the changing flux density in the adjacent air parts of the magnetic circuit. Torsional vibration of the motor is caused by unbalanced windings or applied voltages. Vibration of the rotor simulating a mechanically unbalanced rotor is caused by two fields differing by two poles and not of the same frequency or direction of rotation. Vibration of the stator by distortion from a circular shape results from the presence of other simple combinations of fields. Teeth tend to vibrate axially at double applied frequency.*

*The magnetic noise produced by a motor can be predicted from a qualitative analysis of the air-gap field supplemented by an approximate quantitative analysis and consideration of the stiffness of the parts.*

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## Introduction

Due probably to the previous lack of engineering importance, there is very little information on the subject of noise in electrical machines readily available in our technical literature. When mentioned at all, it is usually covered by a few general, superficial, and, frequently, inaccurate statements. It has been found that these general statements can be made precise by building up an exact theory from elementary fundamental principles.

A motor is a source of sound because some part is moved periodically by a periodically varying force. This axiomatic statement is made to emphasize the fact that the study of noise is a detailed exact study of the parts which can vibrate and the forces which move them.

Magnetic noise (so called) is that in which the forces are those associated with the varying magnetic flux density. We can limit the study to the vibration of magnetic parts produced by the flux in the adjacent air parts of the magnetic circuit. The conductors themselves can usually be neglected as a noise source as the forces on them, being situated in the relatively weak leakage field, are small. Likewise we can neglect whatever internal stress may exist in the magnetic parts as the rigid parts are not deformed appreciably.

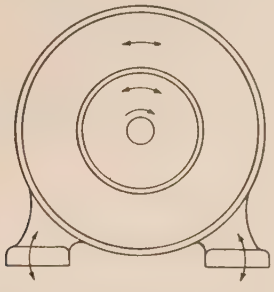

Fig. 1—Torsional Vibration Produced by Two Fields with Like Number of Poles but Different Angular Velocities

The noise producing parts can vibrate in several ways. A torsional vibration of the stator and rotor as a whole results from periodic torque pulsation. Such a vibration may be particularly objectionable as it is transmitted directly through the motor feet to the supporting structure. (See Fig. 1.) Due to the reaction of unsymmetrical supports torque pulsation may also distort the stator from its circular shape. A circular vibration simulating a mechanically unbalanced rotor as shown in Fig. 2 results from an unbalanced magnetic pull. This unbalanced force may revolve in either direction and at other than synchronous or rotor speeds or it may even be stationary. If due to the use of skewed members the phase of the force is not the same for all axial positions it will tend to shake the rotor as well as to bend the shaft, *i. e.*, it simulates two unbalanced weights with different axial and angular positions. The stator may be deflected, as shown in Fig. 3, into a rotating elliptical shape. Similarly, the forces may be balanced on more than two radii resulting in a tendency toward a rotating polygon. The laminations and particularly the teeth may vibrate axially. Experience indicates that teeth seldom if ever vibrate tangentially. The rotor may vibrate axially as a whole, causing noise by striking the bearings.

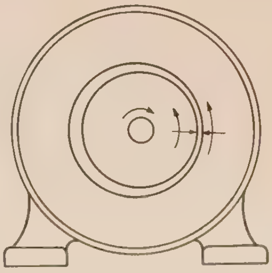

Fig. 2—Rotor Vibration Simulating an Unbalanced Rotor

Most vibrations are forced; *i. e.*, their frequency is not near a critical frequency. In this case the vibration is proportional to the force and inversely proportional to the rigidity of the parts. However, since there are several causes for flux density variation and hence several frequencies of applied forces, there is considerable chance of encountering a critical vibration in which a small force produces a large deflection.

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*Printed complete except for Bibliography omitted.

1. Electrical Engineer, General Electric Company Lynn, Mass.

*Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 27-31, 1930. Complete copy upon request.*

### Magnetic Forces

At every point on the air-gap surface there is a directed varying force proportional to the flux density squared. The summation of the tangential components of force is the total torque. The radial components according to their configuration tend to distort the parts.

As is well known and contrary to elementary text book theory, the air-gap field is at no instant distributed according to a simple sinusoid and the distribution changes as it rotates. This is equivalent to saying that in addition to the fundamental field there are other fields with other than fundamental number of poles and some with other than fundamental frequency.

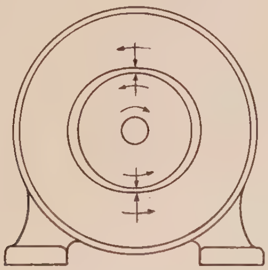

Fig. 3—Elliptical Vibration of Stator

It is evident from consideration of energy that torque pulsations will result from the presence of two fields having the same number of poles and rotating with different velocities. The worst case and possibly the only one which is a serious noise factor is that in which there is a backward revolving field produced by single-phase operation, unbalanced applied voltages, or unbalanced windings.

It has been shown by Fritze[2] and also by Chapman[3] that two fields differing by two poles produce an unbalanced magnetic pull as illustrated in Fig. 2. In Fig. 4 instantaneous values of the radial forces are plotted for a field having a two-pole and a lesser four-pole component to show the superposition of this unbalanced radial pull on the high harmonic force components. The shape of this force curve changes as the fields rotate but there is always present the same radial unbalanced component which may be stationary but which usually rotates. The noise produced is like that of a motor with an unbalanced rotor revolving at the speed of rotation of the unbalanced component.

It can also be shown (see Appendix A) that the combination of two fields differing by four poles or a single two-pole field tends to distort the parts into a rotating ellipse. In general the combination of two fields having poles whose sum or difference equals any given number $g$, or a single $g/2$ pole field tends to distort the stator or rotor into a polygon having $g/2$ sides and usually rotating.

2. *Archiv fur Elektrotecnik*, Vol. 10, pp. 73-95, July 23, 1922.
3. *I. E. E. Jl.*, Vol. 61, No. 313, pp. 39-48, Dec. 1922.

There is always present a double line frequency axial vibration of teeth and punchings best corrected by tight clamping and impregnation. Frequency is double because the forces are proportional to the flux density squared.

The method of determining the noise tendency of a motor is to tabulate qualitatively all of the possibly existing fields and examine for two fields differing by two poles, four poles, etc., or two fields with the same number of poles revolving at different speeds. The disturbing pairs of fields are examined more critically and roughly quantitatively with regard to magnitude, frequency, and rigidity of parts. With these data the quality of the finished design becomes dependent upon the skill of the designer in combining parts to obtain results which can be predicted rather than the chance results of applying less fundamental rules.

It is beyond the scope of this paper to make a thorough study of the air-gap fields except perhaps to enumerate the order of the fields probably existing and the factors upon which their magnitude depends in order to point out how the several design features are related to magnetic noise. The fields existing in an induction motor air-gap may be roughly classified with regard to source as follows.

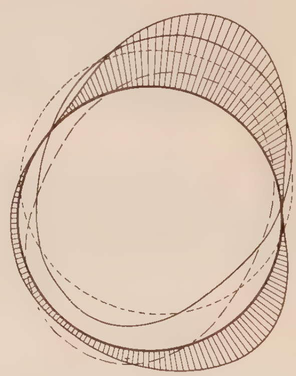

Fig. 4—Radial Face Produced by the Combination of a Two- or Four-Pole Field

Heavy circle is reference zero line
Dotted curve is sin $x$
Dash curve is $\frac{1}{2}$ sin ($2x$ − 15 deg.)
Full line curve is flux density, sin $x$ + $\frac{1}{2}$ sin ($2x$ − 15 deg.)
Radially shaded area represents radial force, $|\sin x + \frac{1}{2}\sin(2x - 15\text{ deg})|^2$.

1. Fundamental for which motor is designed.
2. Stator magnetomotive force harmonics.
3. Stator magnetomotive force sub-harmonics.
4. Rotor magnetomotive force harmonics.
5. Rotor magnetomotive force sub-harmonics.
6. Gap eccentricity permeance variation.
7. Stator slot permeance variation.
8. Rotor slot permeance variation.
9. Permeance variation due to saturation.
10. Slot pattern permeance variation.

As is well known with a symmetrical winding, the magnetomotive force in addition to the fundamental contains harmonics of order, $N = (\pm)(2\phi g \pm 1)$

where $N$ = order of harmonic, $\phi$ = number of phases, and $g$ = any positive integer. The sign indicates the direction of rotation. In a squirrel-cage winding the number of phases equals the number of bars per pair of poles and produces the corresponding harmonic magnetomotive force. A non-symmetrical winding produces other fields having fewer than fundamental number of poles. The magnitude of the magnetomotive force waves is inversely proportional to the order, is proportional to the current in the winding, and is dependent upon the well known pitch and distribution constants. The flux field produced is approximately proportional to the magnetomotive force and inversely proportional to the air-gap unless there is a closed secondary circuit to such a field in either winding. It should be recognized that while the fundamental flux is proportional to the magnetizing current the harmonic flux is proportional to the total current if there is no suitable closed low impedance secondary circuit. In the latter case the flux is greatly reduced.

In addition to these so-called harmonic fields, the presence of slot openings, and other irregularities in the air-gap introduce other disturbances in the flux equivalent to introducing new harmonic fields. These may be called permeance fields. If there are $m$ equally spaced irregularities, the combination of the fundamental magnetomotive force with $2\,N_o$ poles and the $m$'th order permeance variation introduces new fields, the largest having $2\,(N_o + m)$ and $2\,(N_o - m)$ poles. The important permeance fields are given by $m$ equal to one for eccentricity, $m$ equal to the number of stator slots, $m$ equal to the number of rotor slots, and $m$ equal to the difference in numbers of stator and rotor slots. The frequency may be different from fundamental and the fields may rotate in either direction. The magnitude of the field is approximately equal to the magnitude of the disturbance in the even gap permeance; *i. e.*, the amount of eccentricity or the effective slot opening.

## TESTS

Some 1500 motors of about 200 distinctly different designs have been tested with regard to noise. These are assorted over a range of ¼ to 15 hp., 25 to 60 cycles, two- and three-phase, different types of squirrel-cage rotors including single and double windings, slip-ring motors, all overhung slot riveted frame construction. In many cases a motor of a particular rating has been made and tested changing pertinent factors one at a time. As the volume of test results is entirely too large for adequate presentation the following general digest is offered.

No case has yet been found entirely inconsistent with this theory. Only a few cases have been observed noticeably inconsistent. With few exceptions the observed noise has agreed very closely and in detail with that predicted by the methods here presented. The agreement has been particularly good in those cases where a design has been modified to correct an existing noise tendency and in those cases where the design has been changed one factor at a time.

Before presenting any illustrative examples, a description of the method used for measuring noise is in order. It has been found that the human ear and judgment is adequate to measure the disagreeableness of noise if assisted by a standard for comparison. With this standard at one end and the motor being tested at the other end of a room designed with such absorption characteristics as to simulate the absence of walls an observer midway between the two noise sources is impressed equally by them if they are of the same degree of disagreeableness. This method is essentially analogous to the photometer. Contrary to the general impression, the personal error is small and measurements are consistent and adequately precise. In the absence of a commercially recognized unit an arbitrary scale has been used. The scale is an arithmetical progression of disagreeableness such that the noise of the quietest individual commercial motor is recorded as one and that of the noisiest commercial motor about five.

The average of 28 tests on six different sizes of four-pole, three-phase, squirrel-cage motors with 36 stator slots, 7/9 winding pitch and 45 rotor bars, gives a noise reading 1.7 at no-load and 2.4 at full load. The increase in noise with load less rapidly than the primary current is increased would suggest as a cause the combination of primary harmonic fields and permeance fields except that some of the individual motors presumably with even gaps test 1 at no-load and 3 at full load which clearly points to a secondary harmonic field for at least one of the principal noise producing fields. The 23rd stator harmonic with 96 poles and only slightly damped by a 45-bar rotor winding, cooperating with the 94-pole rotor harmonic, the two differing by two poles, constitute the required condition for rotor vibration. The unbalanced pull is proportional to the product of the magnitudes of the two fields. As at no load the rotor harmonic field is zero, the motor is quiet. Under loaded condition both disturbing fields increase and hence the noise rapidly increases.

The use of a 44-bar rotor changes the 94-pole rotor field into one with 92 poles differing by four poles from the 23rd stator harmonic. This constitutes the condition for a rotating elliptical vibration of the stator. However, as the four-pole yoke section is for other reasons quite rigid there should be a distinct improvement. Tests have been made on 17 motors using this 44-bar rotor covering the same range in ratings but averaging 30 per cent larger in horsepower. The average no load noise is 1.3 and the average full load noise is 2. Also, the distinct difference between no load and full load noise in individual machines has disappeared.

A similar case relates to a group of small eight-pole, three-phase, squirrel-cage motors with 48 stator slots, 5/6 winding pitch, and 57 rotor bars. The average of tests on 74 motors gives a noise rating 1.9 at no-load and 2.5 at full load. In this case the noise is

caused by the combination of the 104-pole primary harmonic and the 106-pole secondary harmonic. Changing to 68 rotor bars decreases the noise to 1.2 at no-load and 1.5 at full load as the average of 20 somewhat larger motors.

A group of six-pole, three-phase, squirrel-cage motors with 54 stator slots, 7/9 winding pitch, and 68 rotor bars test consistently 2 at no load and 3 to 4 at full load. The noise is caused by the combination of the 138-pole primary harmonic and the 142-pole secondary harmonic, which differing by four poles, constitutes the condition for elliptical vibration of the stator yoke. Changing to 66 rotor bars gives 1½ to 2 at both no-load and full load.

A group of small eight-pole phase-wound secondary motors with 54 stator slots, 8/9 winding pitch, and 48 rotor slots, 5/6 winding pitch, both wound for three phase, was tested with a poor unsymmetrical primary grouping such as to introduce a backward revolving fundamental field and both two- and four-pole sub harmonic fields with their harmonics. The combination of sub harmonic fields differing by two poles caused very bad rotor vibration. The use of a larger shaft reduced the noise. The arrangement of primary groups was next changed to eliminate the backward fundamental and the two-pole sub-harmonic fields but leaving the four-pole sub-harmonic field. Using the original small shaft, the noise was reduced to 4. In this case the disturbing factors are closely associated with the fundamental field and its harmonics differing by four poles from the four-pole sub-harmonic field and its harmonics. The rotor vibration was practically eliminated but the stator vibration was still present. The stator was next made with a symmetrical winding in a 72-slot stator with a reduction in noise to 2.

Several summarized general statements can be made based on this method of noise prediction and confirmed by tests.

An eccentric air-gap is always a serious noise source as it introduces two new fields with two more and two less than the fundamental number of poles and thus tends to cause rotor vibration. In squirrel-cage motors with few poles these fields are partially damped by secondary currents. An increased air-gap usually decreases noise at the expense of power factor as the permeance variations are decreased and also harmonic fields are less since if undamped they are proportional to the total current in the winding and inversely proportional to the gap.

With otherwise equivalent design a motor with a phase wound rotor is usually more noisy than a similar squirrel-cage machine. The slip ring motor generally has fewer rotor slots with wider slot openings and hence the permeance variations are greater and of a lower order. In a slip-ring motor choice of number of rotor slots is more restricted. A squirrel-cage winding damps many more fields than a polar winding. In a slip-ring machine secondary harmonic and sub harmonic fields are frequently more serious.

Noise is reduced by lower flux density if it is caused by fundamental or permeance fields. In this case the forces are proportional to the square of the fundamental flux density. Other fields depend upon primary or secondary ampere turns and may be decreased or increased by changed fundamental flux density.

The use of skewed rotor slots is an effective means for correcting noise due to high order fields. It can be shown that the skew should be equal to an even number of poles as referred to one field of the pair which is the most serious noise producer. A skew of two poles is reasonably effective although four poles is very much better. This desirable skew is usually equal to the pitch of one or preferably two rotor slots.

As until recently more than ordinary quiet operation has been a secondary consideration and as standard parts must be satisfactory for many ratings, there exists in every manufacturer's line a variation in quietness of particular ratings and a lesser variation in individual machines. This will always be the case as the features which make the quietest machine are frequently incompatible with other desirable features.

### Summary

As a general rule subject to the usual imperfections of generalized statements, the avoidance of a backward fundamental field and pairs of fields of appreciable magnitude differing by two or four poles is conducive to quiet operation. Gaps must be even and concentric. Parts must be rigid and punchings tightly clamped. As a rule subject to imposing unnecessary design restrictions and possible introduction of undesirable torque characteristics a motor will be quieter if the numbers of poles, stator slots, rotor slots, difference of stator and rotor slots, and winding repetitions bear simple multiple relationship and the motor is quieter the larger the greatest common divisor of these factors.

## Appendix A

The radial component of air-gap flux density may be expressed in wave equation form as a series of trigonometric functions of angular position and time.

$$\beta = \Sigma\, \beta_k \cos\,(k\,x - l\,t + \theta)$$

The summation is made for the several necessary values of $k$ and $l$. $2\,k$ is the number of poles of a given sinusoidal component, $l/2\,\pi$ is the equivalent frequency, and $\theta$ is a general phase difference angle.

Assuming that the radial force is proportional to the square of the radial component of flux density,

$$F = (1/8\,\pi)\,[\Sigma\,\beta_k \cos\,(k\,x - l\,t + \theta)\,]^2$$

This force is a function of angular position and time and can be expanded into a series of sinusoids. Let $F_{Mc}$ be be the coefficient of the $M$'th space order cosine term in the expansion of $F$.

$$F_{Mc} = (1/8\,\pi^2)\int_0^{2\pi} [\Sigma\,\beta_k \cos(k\,x - l\,t + \theta)]^2 \cos M\,x\,d\,x$$

Expanding the integrand, the general term is
$\beta_1 \beta_2 \cos (k_1 x - l_1 t + \theta_1) \cos (k_2 x - l_2 t + \theta_2) \cos M x$
in which $k_1$ and $k_2$ may be the same or different.

$F_{Mc} = 0$ unless $k_1 \pm k_2 \pm M = 0$ in which case

$$F_{Mc} \alpha \beta_1 \beta_2 \cos [ (l_1 \pm l_2) t + \theta]$$

The sign of $l_2$ is the same as that of $k_2$ which makes $k_1 \pm k_2 \pm M = 0$

Likewise, if $F_{Ms}$ is the coefficient of the $M$'th space order sine term in the expansion of $F$,

$$F_{Ms} \alpha \beta_1 \beta_2 \sin [ (l_1 \pm l_2) t + \theta]$$

Thus $\quad F_M \alpha \beta_1 \beta_2 \cos ]M x - (l_1 \pm l_2) t + \theta]$

For $M = 1$, *i. e.*, with two fields differing by two poles there is a force simulating a mechanically unbalanced rotor revolving with speed $l_1 - l_2$ tending to displace the rotor or stator as a whole. For $M = 2$, *i. e.*, with two fields differing by four poles there are forces balanced across any diameter, rotating with speed $\frac{1}{2}$ $(l_1 - l_2)$ tending to distort the rotor and stator into a rotating ellipse. Also a single two-pole field produces the same kind of force rotating at speed $l$. Carrying out the suggested mathematical deduction in detail shows that in this case the proportionality constant is one-half that in the case of two fields with unlike numbers of poles. Similarly, with two fields differing by any number of poles or a single field of half that number of poles the rotating forces tend to deform the stator and rotor into a rotating polygon of like number of sides. Forces are proportional to the product of the absolute values of the offending fields.

When the vibration is produced by a single field the noise frequency is twice the frequency of the field. When the force is produced by two fields their frequencies or direction of rotation must be different to cause noise producing vibrations. With two fields revolving in the same direction the noise frequency is the difference in frequencies of the two fields. If the fields revolve in opposite directions $l_2$ is inherently negative and the noise frequency is the sum of that of the two fields. Since most fields are either exactly or nearly fundamental frequency the most common noise frequency is exactly or nearly double applied line frequency.

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Abridgment of

# The Chicago Long Distance Toll Board

BY E. O. NEUBAUER[1] and G. A. RUTGERS[1]

Associate, A. I. E. E. Non-member

*Synopsis.—The long distance telephone office serves to provide a concentration point for intercity telephone communication from a group of local exchanges, and its size will depend largely upon the number of stations served by the local offices.*

*The Chicago toll office, which serves 1,200,000 stations, recently has been replaced largely with new equipment. This equipment, together with correlated improvements in handling toll service at Chicago, is described in this paper.*

*The work of the toll operator in handling toll calls with the new equipment is compared with the former method. It is this change in operating practise which constitutes a major improvement in long distance service.*

*The paper also includes a description of the toll lines entering Chicago, with their equipment arrangements including telephone repeaters, the power plants required to operate this equipment and that associated with the switchboards.*

*The addendum describes the purpose of the auxiliary and special switchboards which are required in large installations only, such as those in Chicago.*

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THE growth of the long distance telephone traffic, along with many improvements in service, have brought about recently certain significant changes in operating practise. Now, in the majority of instances, the long distance toll user may remain at the instrument during the complete progress of his call. From the standpoint of simplicity and convenience to the user this, together with a reduction in the time interval between the placing of the call and the answer of the distant station, from a former average of six to a present average of less than three minutes, brings long distance and local service very closely together.

The accomplishment of this change required careful planning and supervision throughout the Bell System but except in the larger cities did not involve relatively large or expensive equipment rearrangements. Conditions were such at Chicago, however, that the change in practise, together with preparations in connection with the continuing toll volume increase, made it advisable to replace part and remodel the remainder of the existing toll switchboard equipment.

Such action at so large a center constituted a major problem in telephone engineering. It included also various operating and equipment features which, being of the most recent type available, made the new office one of the most complete advanced and within the system. This paper describes action in the new installation and the general operating and toll circuit layout, prefacing this description with a brief outline of the general relationship of the toll plant to that of the system as a whole.

1. Both of the Illinois Bell Telephone Co., Chicago, Ill.

*Presented at the Great Lakes District Meeting of the A. I. E. E., Chicago, Ill., December 2-4, 1929. Complete copy upon request.*

## The General Telephone System

The telephone system is composed of local exchanges with direct completion of calls between stations within the local exchange boundaries and with switched toll line completion of calls between exchanges. As to plant standards and methods of operation, it is unified so that its whole system is as accessible to any one station as to any other, regardless of sizes of exchanges or their remoteness from each other.

At each local wire center the lines or loops from all subscribers' stations, for purposes of their direct interconnection, are brought to one central office switchboard. If, as in large metropolitan areas, this concentration involves too extensive a wire haul, the geographical group is split up into economic sub-areas with sub-wire centers connected together by direct local trunks.

This same general arrangement is supplied for intercity or toll connections. Adjacent and neighborhood communities are connected by direct toll lines, and more widely separated cities receive their toll service through selected toll centers or switching points strategically located throughout the system's territory.

Each toll office is a focus for all originating and terminating toll business from and to its tributary local offices, and the effect of this toll centering is to concentrate toll traffic into units large enough to permit the most economical balance between the costs of the switching operations and the costs of the toll line plant.

The Chicago toll office, at one of the great regional centers of this country, is a key switching point within the countrywide network of toll lines and serves directly the 32 local wire centers with 102 central offices and five suburban wire centers which together form the Chicago Metropolitan Area. Within this area during the year 1929 some 1,200,000 stations will have originated approximately 7,300,000 calls via this toll board, in addition to some 44,500,000 calls which will have been handled by the Chicago local offices to nearby toll points.

## The Work of the Toll Operator

Under the toll centering arrangement, the local and tributary offices are connected with their toll office by groups of recording and toll switching trunks. Prior to the change in the method of toll operation already referred to, the recording trunks terminated on separate recording positions, and a special recording operator worked to secure only the necessary details of the call from the calling subscriber. She then released the subscriber's line and passed a ticket memorandum of the call to separate completing operators at an outgoing switchboard line. These operators re-secured the subscriber over toll switching trunks, reached the distant station over the toll lines, and then established the connection and timed the call.

With the change in method, the recording and completing or "line" operators' functions have been combined and located entirely upon the outgoing switchboard. To indicate this method of combined line and recording work, an expression, "CLR" has been coined telephonically and will be used as such throughout the paper.

Since provision must be made for incoming as well as outgoing traffic, and for toll center to toll center switching, we shall generally find that the larger toll switchboards are divided into three groups, or lines; for CLR or originating business, for "inward" or terminating business, and for "through" or switched business. As in Chicago, there are apt to be also various additional special groups to meet the functional requirements of such large toll line and toll volume concentrations as are there encountered.

In handling a CLR call from a manual subscriber, the CLR operator makes a permanent ticket record of the call details and then, without releasing the subscriber from the recording trunk, rings out over an idle toll line to the distant operator, using a separate pair of cords and asking for the station called. While waiting for the called station's answer, she secures the calling subscriber's line over a toll switching trunk, using the same pair of cords used to ring out over the toll line, and releasing the recording trunk. Upon receipt of an answer by the called station, she stamps the ticket with the time in hours, minutes, and seconds with a calculagraph stamp, and upon receipt of the final disdisconnect signal, stamps the time when conversation ended. Billing is finally made upon the basis of charges applied to the elapsed time indicated on the ticket.

One of the chief savings in time to the subscriber under this procedure as compared to the former separate recording and completing operation is the saving in ticket distribution time between the two sets of operators.

Reciprocal work must be done at the terminating end of each originating connection by an inward operator who answers the incoming toll line signal and reaches and rings the station called by the originating toll operator. In handling switched calls, the intermediate or through operator deals only with the distant toll operators who reach each other over toll lines routed via the intermediate toll center board, these lines being connected together at the through positions by the through operator.

Toll calls are handled on the basis of connection with a particular person (a person-to-person call) or with someone who may answer at the station called, (a station-to-station call). Either class of service is available to the subscriber whether he calls by name or by number. When anyone will suffice, the call is necessarily completed upon the answer of the station called and will be delayed only by a "don't answer" or "busy" condition at the station called, or by toll circuit congestion. On a person-to-person call, the inability to reach immediately the one person desired at the telephone may cause delay in addition to the above causes.

The various operations required to secure completion under conditions of postponement involve many different methods and routines which are rather technical in their applications and require additional distributions of the ticket memoranda and various specilization of work.

## The Chicago Toll Board

An example of the specialization required is given in the following tabulation of the Chicago Toll Board positions:

| | | | |
|---|---|---|---|
| (a) CLR | 301 | (f) Directory | 44 |
| (b) Non Method | 233 | (g) Routing | 16 |
| (c) Utility | 78 | (h) Delay Quoting | 4 |
| (d) Inward | 89 | (i) Traffic Trouble | 4 |
| (e) Through | 113 | (j) Office "B" | 6 |
| Total General | 814 | Total Miscellaneous | 74 |

| | |
|---|---|
| (k) Ticket Distributing | 24 |
| (l) Ticket Filing | 24 |
| (m) Service Supervisor | 16 |
| (n) Service Observing | 20 |
| (o) Monitor Tap | 1 |
| Total Auxiliary | 85 |
| Total Tandem | 16 |

These switchboards, which are grouped upon six floors of one building centrally located in the downtown business district of Chicago and designed for an initial service of some 32,000 toll board calls per day, are arranged to accommodate the following line and trunk equipments:

| | |
|---|---|
| 1. Toll line to all points | 2700 |
| 2. Switching trunks to local offices | 3800 |
| 3. Recording trunks from local offices | 850 |
| 4. Miscellaneous interboard trunks | 1200 |
| Total network | 8550 |

Each of the switchboard position and line group arrangements has specific functions which are somewhat abstract for the scope of this paper. Certain controlling factors, however, should be pointed out here as follows:

*Subgrouping and Tandem Arrangements.* The capacity of the face equipment of the CLR boards is insufficient to accommodate the whole of the recording and switching trunks on a workable basis. The CLR group, therefore, has been subgrouped into four units, each of which serves a specific subdivision of the Chicago local offices.

In spite of various measures taken to reduce the space requirements for front equipment at the CLR position, it did not appear practicable to provide appearances for all of the toll lines at each CLR position. Therefore, a trucking plan which introduces a toll line switching on tandem board within the office itself is necessary and the CLR operators thus reach a majority of the toll lines needed by them on a trunking basis. One of the lines of CLR positions is shown in Fig. 1. This line consists of 65 positions.

*Directory and Routing Arrangements.* More than 2100 directories covering 350 metropolitan areas and communities extending from coast to coast are indexed and filed on a state basis at a line of director switchboards. The CLR, or other service operators, communicate with the directory operators by trunks without delay for such telephone number information as cannot be furnished by the subscriber himself.

At certain other positions other operators specialize in quoting the routes to points not obtainable on a direct connection basis. These routines are based on frequent and through traffic engineering studies of the entire toll network throughout the territory involved.

*Pneumatic Tube System.* Because of the location of the various switchboards on several floors, it is necessary that means for rapidly transmitting tickets from one location to another be provided. An exhaust blower, a system of flat brass tubes, and ticket distrib-

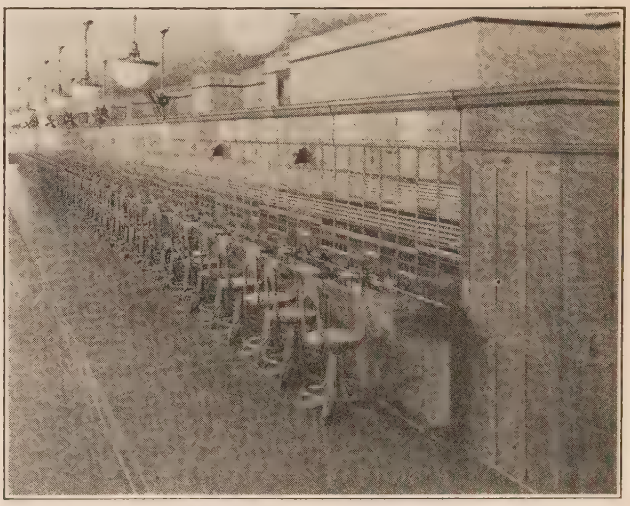

Fig. 1—A Line of CLR (Combined Line and Recording) Switchboard

uting positions comprise a pneumatic tube system for this purpose. With one end folded to form a pocket for the tube air currents, the tickets are inserted at any position and delivered to control or distributing positions where they are checked and routed to their proper destination. Either roller or hand receiving valves permit ticket egress at the terminal points.

*Engineering Problem Involved.* Consideration of the situation at the Chicago center had established the fact that the increasing toll volume growths would require equipment floor space in excess of that which could be made available without additional building operations. In 1926 it appeared that the rather appreciable equipment additions required for growth and those required to permit of change to CLR operation would tend to advance the new building work and would require new switchboard line arrangements to permit this to be readily carried out.

At this same time, new and improved toll switchboards of a more efficient type were being made available, and it was desirable to utilize this type even though they could not be used in conjunction with the existing type boards without appreciable modifications within the latter. After proper engineering cost study and management consideration, these various factors combined to indicate that the dismantling losses upon part of the existing switchboards and the new money requirements could be justified on the basis of improved efficiencies in service and over-all economies in providing for future growth. Since a clear path for future building work could also be secured, it was decided that the old switchboard be practically replaced.

The general building conditions were such that the new switchboards, when completed, would to a great extent be occupying the old switchboard space, and yet service upon the old boards must be kept up on a continuous basis. This was met by the invention of special "applique" circuits, attachable to the old board circuits to make them workable with the new board circuits. By this means, as installation work proceeded, the old and new were placed side by side and the service was continuous and yet made ready for cut-over.

The problem in connection with the congested face equipment space of the CLR boards which, as already mentioned, resulted in a toll tandem board arrangement, brought into service an entirely new development designed especially for metropolitan CLR offices.

It was felt also that all other equipment or operating improvements available should be included in this one big project. Under this head came the terminal repeater pad arrangement to eliminate cord circuit repeaters, and this was added to the already complicated plans for Chicago.

Under normal conditions, each step in the development of new equipment and operating methods is worked out in a preliminary manner and given a complete workout on a trial basis. If satisfactory, requirements then are worked out on the basis of manufacturing production and given to the field. Field engineering considers these in connection with existing and potential conditions and includes them in cost and other studies which result in detailed specifications. Then the manufacturing company carries out its detailed engineering and manufacture in accordance, ships the material, and installs it.

*Toll Line Equipment.* The replacing of No. 3 type of toll switchboard has its toll line signaling units included with the toll line circuit, thus omitting them from the cord circuits in the switchboard and in many cases eliminating the association of ringers with the toll line terminal equipment. This feature required the development of the "applique" devices for use in working old and new sections temporarily together, as already referred to. Fig. 4 shows the arrangement of equipment and cross-connections in a toll line and toll switching trunk.

In line with the switchboard replacement, all of the existing toll lines at Chicago required practically complete retermination and realinement, while on a working basis to meet both old and new conditions. This covered some 3122 signaling units, 2450 toll line circuits and 974 two-wire and 1210 four-wire repeaters with their associated networks and equipments. A feature of this work was the necessary coordination by many distant toll line offices and their terminal arrangements.

*Repeater Pad Control.* For many years, necessary amplification of the speech currents on toll circuits switched at the toll office for the longer distances has been provided by the use of manually-operated repeaters of the cord circuit type available for insertion in the line as required. Under the conversion at Chicago, these were completely displaced.

The plan carried out to displace the cord circuit repeaters and to obviate certain operating difficulties requires the operation of the toll lines at transmission equivalents low enough to permit switching without cord circuit repeaters. Since, in many toll lines, this would involve noise and crosstalk when they are used

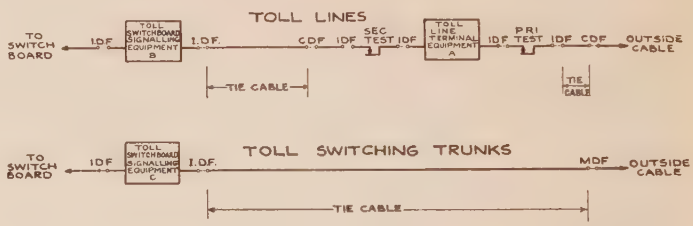


FIG. 4—DIAGRAM SHOWING ROUTING OF LINES FROM OUTSIDE CABLE TO SWITCHBOARD

*CDF* = combination distributing frame; *IDF* = intermediate distributing frame; *MDF* = main distributing frame

on terminal connections, the power level of such a line when used for a terminating connection is reduced by the insertion of a pad. The plan, therefore, requires circuit arrangements so that the pad will remain in the line when it is used on a terminal connection but will be removed from the line when it is switched to another toll line on a via connection.

*Multiple Cut-off.* Where the boards are located on several floors, the amount of wiring necessary to connect lines in a large switchboard installation introduces transmission losses due to the bridged multiple; this is objectionable. Arrangements have been made, therefore, to cut off some of the boards for through connections, and this is accomplished by so wiring the switchboards that they may be divided into two groups; (1) those at which switches to other toll lines are never made, and (2) those at which switches to other toll lines are made. A relay system is then provided so that when a circuit is taken up at any position of group (2), the multiple of the positions in group (1) is cut off. This arrangement is shown diagrammatically in Fig. 5.

## TESTING

The testing and correcting of troubles on lines and

equipment in so large a concentration requires appreciable specialization. A total of 46 primary and 20 secondary units of No. 5 type toll test board is provided for this purpose, with segregation between toll cable and toll open wire terminations. The primary units test against outside, and the secondary units against inside office trouble.

In addition to the routine tests made at frequent intervals by the maintenance people, routines have been set up for reporting the troubles of various kinds which are noted by the operators. These provide for

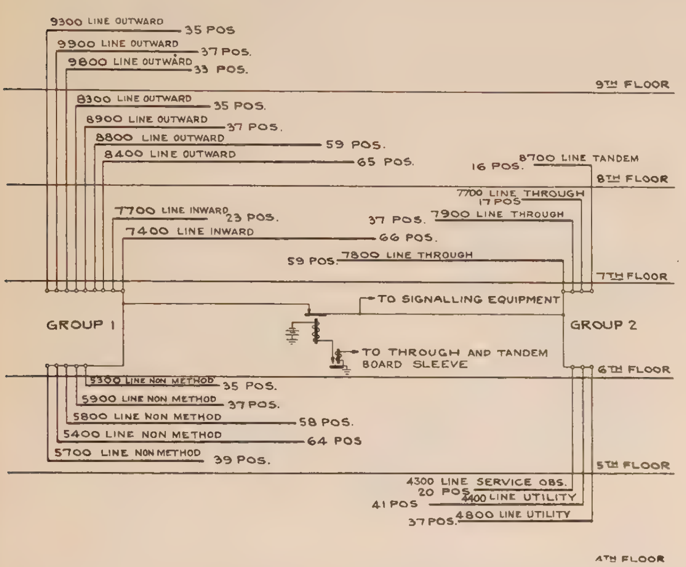


Fig. 5—Diagram Showing Connection for Multiple Cut-Off

the prompt reporting of all such troubles to the proper plant maintenance people who take immediate steps to clear up any unsatisfactory conditions.

*Power Plant.* The toll line terminal equipment requires two 24-volt batteries arranged in parallel with a 6400-ampere hour capacity and a present peak load of 850 amperes; 130-volt storage battery unit, with a 640-ampere hour capacity and a peak load of 75 amperes for the plate voltage of vacuum tubes and for telegraph, and two 1000-cycle and two 135-cycle generators to supply the necessary alternating current for signaling purposes.

The toll switchboard equipment is operated by another 24-volt storage battery unit with an existing peak load of 1350 amperes; a 28-volt battery used for busy signals, with a 1900-ampere drain in the busy hour a 130-volt battery for vacuum tube plate current with a 1.5-ampere drain and a 48-volt battery for special circuits with a 5-ampere drain. All of these batteries are maintained on a continuous float basis and are provided with voltage regulators. D-c. power supply operates the charging generators. Alternating ringer current for signaling purposes is here supplied by four 1000-cycle, two 135-cycle and two 20-cycle ringing generators.

The exhauster used for operating the pneumatic tube system is operated by an 85-hp. motor with a speed of approximately 3500 rev. per min.

*Toll Line Facilities.* The Chicago toll office is the center for 20 toll cables entering over six main underground routes and terminating 1949 quads on the cable test boards.

There are in addition 152 open-wire circuits which reach the open wire test board after their preliminary transfer at the city limits to necessary underground toll entrance cables. The routing of the open wire lines is shown in Fig. 7.

At the toll open wire entrance point, there are now installed, therefore, besides the necessary open wire terminal equipment and 132 telephone repeaters, 192 channels of carrier telegraph and 37 systems of telephone carrier.

In addition to the 1400 toll lines now in service within toll cables there are 590 telegraph channels in service

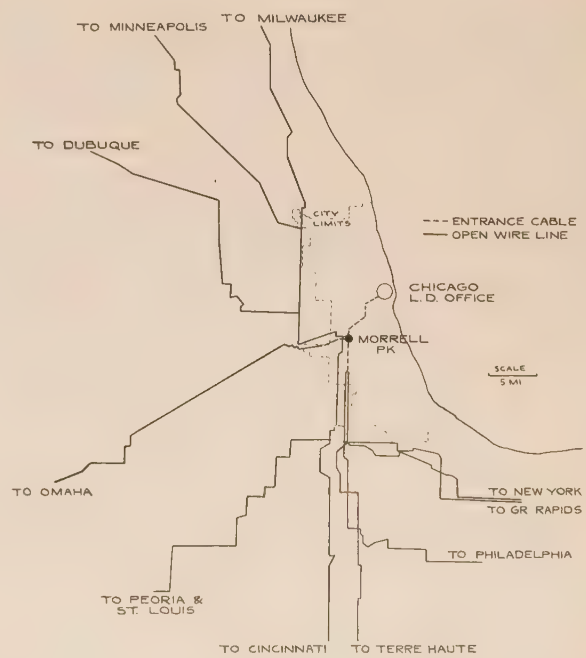


Fig. 7—Route of Open-Wire Lines Entering Chicago

in these same cables. Of these 300 are superimposed on wires used simultaneously for telephone circuits and the remaining 290 are provided upon carrier current channels on wires which cannot simultaneously be used for talking purposes.

## Conclusion

Within this toll system plan, the continual objectives are those of simplification and improvement in methods, increase in speed and accuracy of service, more complete efficiency in the provision and use of plant, and uniformity of transmission between all points.

The marked and steady increases in toll business at Chicago and throughout the country, and the several reductions in toll rates which have been made in recent years are rather direct evidence that these technical objectives are being met to the increased comfort and satisfaction of the subscriber whose point of view is, in the last analysis, the final and ultimate control.

Abridgment of

# The General Circle Diagram of Electrical Machinery

BY FREDERICK EMMONS TERMAN,*
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Non-member
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***Synopsis.***—*The well-known circle diagram of a transmission network is applied to electrical machinery, giving circle diagrams of alternators, synchronous motors, synchronous condensers, and transformers. These diagrams give a graphical representation of the machine performance under all possible conditions. Such quantities as power loss, lower input, power output, field current., etc., for any operating condition, can be obtained by inspection. These diagrams have the same field of usefulness as the circle diagram of the inductionmotor.*

*The transmission network circle diagram can be applied to the induction motor, yielding in the approximate representation the Heyland diagram, which is merely a special case of the more general diagram. The transmission network method of attack gives a straight-forward solution to many induction motor problems that would otherwise be difficult to handle; such as a motor equipped with a phase advancer.*

* * * * *

ANY electrical network connecting two pairs of terminals can have its electrical characteristics represented graphically by a transmission line type of circle diagram.[1] This same circle diagram can be used to show the performance of alternators, synchronous motors, transformers, and synchronous condensers with the same advantages that are already well known in the case of the transmission line and induction motor circle diagrams.

The transmission network circle diagram is applied to such electrical equipment by substituting an equivalent electrical network for the machine, and then drawing a circle diagram for this network in the usual manner.

## Transformer Circle Diagram

A transformer circle diagram can readily be drawn using one of the well-known equivalent transformer networks. Such a diagram gives the efficiency, regulation, power loss, etc., for all possible load powers and power factors.

The performance of a synchronous motor can be shown by a circle diagram based on the equivalent circuit of Fig. 1, which represents one phase of the machine. In this, $E_r$ is the actual induced phase voltage as determined by air-gap flux, $E_s$ is the sending or terminal phase voltage, which is constant in the case of a motor, $X_a$ and $R_a$ are the armature leakage reactance and effective a-c. resistance (including armature copper and stray-load losses), respectively, per phase, while the iron losses are accounted for by the conductance $G$. Thus the motor is reduced to a transmission network through which power is transmitted with a sending end voltage of $E_s$ and a receiving voltage of $E_r$. The power which in the equivalent circuit of Fig. 1 is delivered to the receiving voltage, is the mechanical power produced by the motor, and so is the shaft output plus the windage and friction. The motor losses exclusive of field loss are the losses in the equivalent circuit plus the windage and friction.

The network constants corresponding to Fig. 1 are

$$\begin{aligned} A &= 1 + G\,(R_a + X_a) \\ B &= R_a + X_a \\ C &= G \\ D &= 1 \end{aligned} \qquad (1)$$

In a given machine, the usual stray power test will give $R_a$, $G$, windage, and friction. The iron losses can be

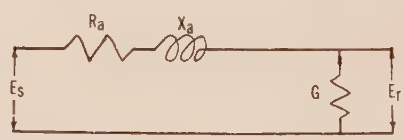


Fig. 1—Equivalent Circuit of Synchronous Motor and Synchronous Condenser

$R_a$ – Series resistance representing armature copper and load losses
$X_a$ – Series reactance representing armature reactance
$G$ – Shunt conductance representing iron losses
$E_s$ – Terminal voltage
$E_r$ – Induced voltage

represented by a conductance placed as shown in Fig. 1, because these losses are very nearly proportional to the square of induced voltage (and hence of air-gap flux). Since Fig. 1 applies to only one phase of the machine, in a polyphase motor the total iron losses are divided equally among the phases. An iron loss of $P_i$ watts at an induced voltage of $E_r$ in an $N$-phase machine accordingly leads to a conductance $G = (P_i/N)/E_r^2$. The leakage reactance $X_a$ can be computed, or can be obtained approximately by measurement. The fidelity of the circle diagram is fortunately not appreciably affected by reasonable uncertainties in the value of $X_a$.

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1. Evans and Sels, *Power Limitations of Transmission Systems*, Transactions of A. I. E. E., 1926, Vol, 43, p. 26. Also a series of articles by Evans and Sels in *Electric Journal* of 1921.
Terman, F. E., *The Circle Diagram of a Transmission Network*, Transactions of A. I. E. E., Vol. 45, p. 1081, 1926.

The circle diagram of the synchronous motor is based on the network constants of Equations (**1**), and is constructed in the usual way, using a constant terminal voltage and a system of input power—reactive power coordinates. There is, however, considerable flexibility possible in the labeling of the diagram. Thus, although the equivalent circuit, and hence the diagram obtained from it, apply only to a single phase, it is possible to label this single-phase diagram with the corresponding

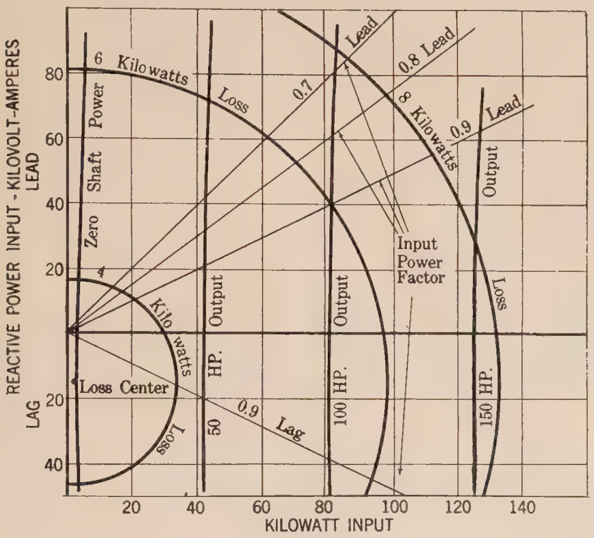

Fig. 2—Circle Diagram of 100-Hp. Synchronous Motor

three-phase quantities. The practical way of doing this is to compute the circle centers and radii on the single-phase basis; then lay out a coordinate system calibrated directly in three-phase power quantities and draw the circles using radii and center coordinates three times the calculated single-phase values. The circles themselves can also be marked with the corresponding three-phase values. Thus, a circle representing a single-phase loss of 10 kw. can be marked 30 kw. on the three-phase diagram, and will then represent total three-phase loss.

The circle diagram as derived from Fig. 1 does not include windage and friction losses, but can be made to do so by a simple expedient. Since these losses represent mechanical power developed in the machine, but not available at the shaft, they can be taken into account by suitably labeling the diagram; that is, a loss circle would be drawn to represent a certain network loss but would be labeled with this loss, plus the windage and friction loss, and an output power (receiver power) circle drawn representing a circle mechanical power output would be labeled with this power minus windage and friction, to give actual net shaft power.

The circle diagram of a 100-hp. synchronous motor is shown in Figs. 2 and 3, in which the labeling is in terms of three-phase quantities, and includes windage and friction. To avoid confusion, the motor diagram has been divided into two parts, but by the use of colored inks, all necessary loci could satisfactorily go on one figure. It is of course understood that Figs. 2 and 3 do not show all the circular loci that could be drawn. Loci giving input current, induced voltage, angle between terminal and induced voltage, etc., could have been included.

The usefulness of the synchronous motor circle diagram is greatly increased by superimposing constant field current lines upon the power—reactive power coordinate system, as has been done in Fig. 3. The location of these lines can be obtained by either measuring or computing the combinations of reactive and real power that, with the field current in question, will give the terminal voltage for which the diagram is drawn. The field current loci are approximately circular arcs and would be exactly circles if the armature reaction could be truly replaced by an armature reactance of constant value.

The circle diagram as described does not take into account field copper loss. It is possible, however, to mark each field current line with the corresponding field loss, and in this way to obtain from the circle diagram the total power loss of the alternator for a given load power and power factor. The procedure is to locate the point on the coordinate system corresponding to the desired load conditions. The field current line passing through this point shows the field power and the loss circle at the point gives the other losses (*i. e.*, wind-

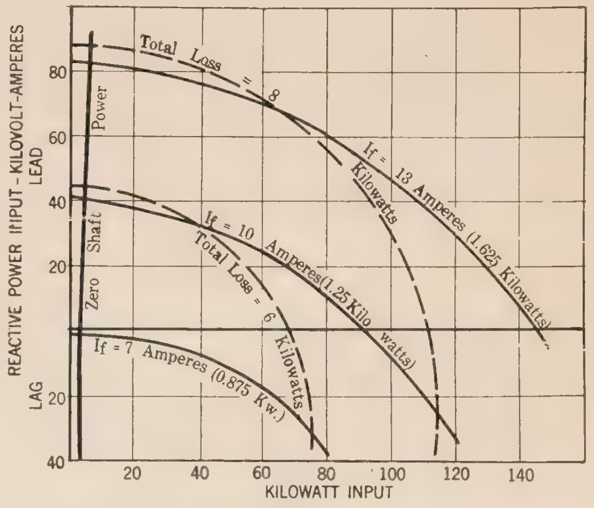

Fig. 3—Circle Diagram of 100-Hp. synchronous Motor (Fig. 2 continued)

age, friction, armature copper, load, and iron) so that the total loss is the sum of these components. It is also possible to draw total loss loci, several of which are shown in Fig. 3. These lines are computed point by point from the loss circles and field current lines, and are almost, but not exactly, circular.

The accuracy of the motor circle diagram is approximately that of the usual stray power test method. The fundamental assumptions are; (1) iron losses are considered proportional to the square of the induced

voltage and independent of armature current; (2) load losses are assumed proportional to the square of the armature current; and (3) the armature is assumed to have a constant leakage reactance. None of these assumptions introduce appreciable error.

The performance of alternators and synchronous condensers can be obtained from circle diagrams similar in character to the synchronous motor diagram.

THE INDUCTION MOTOR

Reducing the induction motor to an approximately equivalent network and drawing a circle diagram for this network leads to the usual Heyland diagram. The usual induction diagram turns out to be merely a very special case of the more general circle diagram of a transmission network. The transmission network method of attack, while having no special advantages over the customary construction in ordinary cases, gives a direct and simple procedure for handling the more complicated induction motor problems, such as the exact circle diagram, or a motor equipped with a phase advancer.

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**Abridgment of**

# Magnetic Circuit Units

BY ARTHUR E. KENNELLY*

Fellow and Past-President, A. I. E. E.

***Synopsis.***—*A proposition to introduce a change in the units of the magnetic circuit was made at the meeting of the International Electrotechnical Commission, (I. E. C.) in Bellagio, September 1927. The proposition was referred to an international subcommittee for consideration and report, by the Advisory I. E. C. Committee on Nomenclature. The subcommittee has recently reported, recommending that the matter be placed on the agenda of the next I. E. C. meeting, and that in the meanwhile, the subject should be discussed in all the national committees, more especially in the various electrical engineering societies, so as to pave the way for well considered international action. This paper has been prepared in the hope of presenting the questions definitely, with a view to eliciting discussion and opinions that may be helpful from the international point of view.*

*As an aid to the formulation of views on the subject among those who may not have given special attention to the historical development of the magnetic-circuit units, a short outline of their history is here submitted.*

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*Recent International Proposals.* At the meeting of the International Electrotechnical Commission (I.E. C.) at Bellagio in September 1927, the Italian delegation submitted[1] a proposal to establish a new international unit of magnetic flux $\phi$ in the[2] "practical system," with a magnitude of $10^8$ C. G. S. magnetic units, or corresponding to what is sometimes called a "volt-second," and to assign to this new unit of flux the name "maxwell."

After some discussion, the matter was referred to an international subcommittee of seven, (representing the national I. E. C. committees of France, Germany, Great Britain, Holland, Italy, Russia, and the United States) for consideration and report to the I. E. C. Committee No. 1 on *Nomenclature.*

The subcommittee discussed the matter by correspondence distributed through the General Secretary's office in London, during 1928 and 1929. It presented a report in September 1929 to Doctor Mailloux, the president of the I. E. C. Nomenclature Committee. A copy of the report is appended to this paper.

*Need for General Consideration and Discussion.* From the correspondence among the members of the international subcommittee, it was evident that although no official change has been made in the international status of magnetic-circuit units since the Paris International Electrical Congress of 1900, yet there exists a considerable difference of usage of magnetic units in the various countries, not merely as to the names, but also as to the definitions of the units. It is therefore in the interest of all countries that the whole question of the magnetic units and their names should be considered afresh, with a view to arriving at a sound, simple, and satisfactory international agreement upon the same. While, therefore, the subcommittee could not endorse the proposal to change the value of the *maxwell* from 1 C. G. S. to $10^8$ C. G. S. units of magnetic flux $\phi$, it recommends that the matter be discussed in all the 25 countries participating in the I. E. C., particularly among their engineering societies, in order to elicit useful suggestions and to pave the way for well considered international action. This paper aims to present a brief history[3] of the development of the magnetic-circuit units, especially during the last 40 years, in so far as may be helpful in visualizing the present status of these units to indicate the reasons existing for

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1. Bibliography 29, pp. 121-123. Report of I. E. C. Meeting at Bellagio.

2. The term "practical system" as here used, refers to the series of international electrical units, substantially as adopted at the Electrical International Congress of Chicago in 1893; *i. e.*, the international volt, ohm, ampere, etc.

*Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 27-31, 1930. Complete copy upon request.*

3. For this historical outline, see complete paper.

changing that status and to submit a few suggestions in that direction by way of starting the discussion in the American Institute of Electrical Engineers.

*Contribution to the Discussion on Future Desirable Action of the I. E. C.* The following remarks are submitted from the standpoint of an advocate for a particular course of I. E. C. action in the matter, as a contribution to the general discussion.

*First.* Before any definite new action is taken, it is desirable to standardize internationally the definitions of magnetomotive force, magnetizing force, magnetic reluctance, magnetic flux, and, especially, permeability, so as to reach international agreement upon the dimensions of permeability.

In the Giorgi and C. G. S. S. systems, it appears that permeability is a product $\mu_0 \mu$ of space permeability $\mu_0$, or the permeability of a vacuum, and specific permeability $\mu$, that of the magnetic circuit with respect to free space. Space permeability $\mu_0$ will probably be generally admitted to have dimensions; while specific permeability $\mu$ is probably a mere numeric. Perhaps on such a basis, definitions may be drawn which will secure universal endorsement.[30]

*Second.* It seems desirable to revise internationally the assignment of names to a few magnetic units in the C. G. S. system. With the dimensions of permeability established, the question whether the *gauss* can apply to both $H$ and $B$ can be decided. Concerning the *maxwell*, as adopted at Paris in 1900, there has been neither dispute nor confusion. It is true that in some countries the *maxwell* has been little used, but it has been considerably used in other countries. Its proper use should not be interdicted. Whatever new action may be taken in the near future, we must expect to see C. G. S. magnetic units continue to be used for a long time.

*Third.* It would be desirable to accept part of the Italian delegation's proposal at Bellagio in 1927, and to adopt a "practical" unit of magnetic flux at the value of $10^8$ C. G. S. units; but not to call it the *maxwell*, which name since 1900 has been reserved for the C. G. S. unit. Giorgi, in his papers of 1901-1904, suggested the name *weber* for this "practical" unit, and Bennett, in 1917, also suggested the name *weber* for the same C. G. S. S. "practical" unit. The name would have to be agreed upon internationally. For the present we may call this unit the *volt-second.*

It does not seem likely that the adoption of the *volt-second*, with its appropriate new name, would seriously conflict with the *maxwell* in practical use; their magnitudes are so remote. The advantage would be that the path would be opened for electrical workers to employ either the Giorgi or the C. G. S. S. comprehensive practical system, without reference to the C. G. S. units, if they desire to do so. The ampere-turn as a rationalized unit of m. m. f. in both these systems already exists and probably needs no other name. The difficulty comes when an attempt is made to adopt the corresponding "practical" unit of flux density, whether with or without a special name. If the unit of flux density be chosen as the volt-second per square meter, it fits into the Giorgi M. K. S. $\Omega$ system and virtually fixes upon that system exclusively. If, on the other hand, the unit of flux density is chosen as the volt-second per sq. cm., it fits in with the Karapetoff-Dellinger-Bennett "International" C. G. S. S. system and, logically, would fix upon that system. It would seem to be sufficient at this time to leave the path open for the use of a comprehensive system without fixing upon the system or on its series of units. If, however, a choice should be made at once, then, in the opinion of the writer, the meter and kilogram are to be preferred over the centimeter and gram-seven.

If a comprehensive system such as the M. K. S. $\Omega$ system developed and found favor with electrical workers, it would greatly simplify electromagnetic theory, for teachers, students, readers, and writers, since we should all be able to abandon the existing duality of the C. G. S. and the derived "practical" units. It might well happen that the new comprehensive system would carry all before it and so far as electrical workers are concerned, relegate the C. G. S. system to history and the shelves. In that case, the comprehensive system, being also adapted for use in mechanics, chemistry, optics, and all other branches of science, might readily invade those branches and ultimately replace the C. G. S. units they use with M. K. S. $\Omega$ units. The numerical changes thus effected in tables and formulas would in nearly all cases be decimal changes or a shift of the decimal point. Such a change, if it occurred, would probably come very slowly and take many years to effect. Nevertheless, when it is remembered that all science is so closely interlaced through its units that what happens to the units in one branch may readily react upon the unitology of other branches, it seems desirable not to take final steps of change in any region without giving ample notice to the workers in others. In all countries, all are interested.

At present, no comprehensive system of units can make headway in the magnetic circuit so long as by international agreement the magnetic-circuit units are wholly in the C. G. S. system. If a new unit of flux is created, with a name, in the "practical" series, that obstacle would be removed. If the comprehensive system utilizes this and develops useful service to the world in the next few years, then subsequent I. E. C. action can adopt the comprehensive system and set the C. G. S. system aside. If, however, for any reason, the comprehensive system fails to find favor, the volt-second unit will probably not come into use and might later be withdrawn. The C. G. S. system might then continue.

*Table II*, in parallel columns, offers a comparison of corresponding units in the fundamental C. G. S. magnetic system and three "practical" systems; *i. e.*, the Q. E. S. system of Maxwell, the Giorgi system, and the more recent "International" system of Dellinger, Ben-

nett, and Karapetoff. The C. G. S. electrostatic system has been omitted to save space.

All three "practical" systems are represented as being rationalized by the removal of the $4\pi$ factor from magnetomotive force and inserting it into reluctance, so as to keep the unit of flux correct. This method of rationalization did not become available until about 1893, and did not appear in the original scheme of Maxwell; but the comparative relations of the three systems are best presented by applying the same rationalization to all alike. Likewise, all three are presented as unified systems through the Giorgi device of adopting suitable values for the space coefficients $\kappa_0$ and $\mu_0$.

The units appearing in italics in the table have names that have been internationally adopted, or may claim to have met with international recognition. On the contrary, the names in Roman type have not been adopted internationally nor are they descriptive only.

The numerical values appearing in Columns VI, VIII, and X indicate the number of C. G. S. units contained in the practical unit considered, except in the case of $\kappa_0$, No. 33, which gives the values of that coefficient in the three different "practical" systems.

TABLE II

TABLE OF FUNDAMENTAL C. G. S. UNITS AND OF THREE DERIVED "PRACTICAL" SYSTEMS

| | | | Fundamental | ← | | Practical | | | → |
|---|---|---|---|---|---|---|---|---|---|
| No. I | Quantity II | Symbol III | C. G. S. IV | Q. E. S. Maxwell, 1881 V | In C.G.S.U. VI | M. K. S. Ω Giorgi, 1901 VII | In C.G.S.U. VIII | C. G. S. S. Dellinger-Bennett IX | In C.G.S.U. X |
| | *Mechanic* | | | | | | | | |
| 1 | Length | $L$ | *cm.* | quadrant | $10^9$ | *meter* | $10^2$ | *cm.* | 1 |
| 2 | Mass | $M$ | *g.* | eleventh-g. | $10^{-11}$ | *kilogram* | $10^3$ | g.-seven | $10^7$ |
| 3 | Time | $Q$ | *second* | second | 1 | *second* | 1 | *second* | 1 |
| 4 | Area | $S$ | *sq. cm.* | sq. quad. | $10^{18}$ | *sq. meter* | $10^4$ | *sq. cm.* | 1 |
| 5 | Volume | $V$ | *c. c.* | cubic quad. | $10^{27}$ | *cub. m.* | $10^6$ | *cu. cm.* | 1 |
| 6 | Density | $d$ | *gm./c. c.* | eleventh g/quad.$^3$ | $10^{-38}$ | *kg/m.$^3$* | $10^{-3}$ | *g$^7$/c. c.* | $10^7$ |
| 7 | Velocity | $v$ | *cm./sec.* | quad./sec. | $10^9$ | *m/sec.* | $10^2$ | *cm/sec.* | 1 |
| 8 | Acceleration | $a$ | *cm./sec.$^2$* | quad./sec.$^2$ | $10^9$ | *m/sec.$^2$* | $10^2$ | *cm/sec.$^2$* | 1 |
| 9 | Force | $F$ | *dyne* | centidyne | $10^{-2}$ | dyne-five | $10^5$ | dyne-seven | $10^7$ |
| 10 | Pressure | $p$ | *dyne/sq. cm.* | cntdyne/sq. quad. | $10^{-20}$ | dyne-5/sq. *m.* | 10 | dyne-7/sq. cm. | $10^7$ |
| 11 | Torque | $Q$ | *dyne ⊥ cm.* | cntdyne ⊥ quad. | $10^7$ | dyne-5 ⊥ *m.* | $10^7$ | dyne-7 ⊥ cm. | $10^7$ |
| 12 | Moment of Inertia | $J$ | *g.-cm.$^2$* | 11th-g-quad.$^2$ | $10^7$ | *kg-m.$^2$* | $10^7$ | *g-cm.$^2$* | 1 |
| | *Energetic* | | | | | | | | |
| 13 | Work | $W$ | *erg* | *joule* | $10^7$ | *joule* | $10^7$ | *joule* | $10^7$ |
| 14 | Power | $P$ | *erg/sec.* | *watt* | $10^7$ | *watt* | $10^7$ | *watt* | $10^7$ |
| | *Thermal* | | | | | | | | |
| 15 | Heat | $H$ | *g-calorie* | 11th-g-cal. | $10^{-11}$ | *kg-calorie* | $10^3$ | *g-calorie* | 1 |
| 16 | Temperature | $t$ | *Deg. C. or Abs.* | *Deg. C. or Abs.* | 1 | *Deg. C. or Abs.* | 1 | *Deg. C. or Abs.* | 1 |
| | *Luminous* | | | | | | | | |
| 17 | Flux | $F$ | *lumen* | *lumen* | 1 | *lumen* | 1 | *lumen* | 1 |
| 18 | Illumination | $E$ | *phot* | lumen/quad.$^2$ | $10^{-18}$ | *lux*, lumen/m.$^2$ | $10^{-4}$ | *phot* | 1 |
| 19 | Intensity | $I$ | *int. candle* | *int. candle* | 1 | *int. candle* | 1 | *int. candle* | 1 |
| 20 | Brightness | $B$ | candles/cm.$^2$ | candles/quad.$^2$ | $10^{-18}$ | candles/m.$^2$ | $10^{-4}$ | candles/cm.$^2$ | 1 |
| 21 | Focal Power | | cm.$^{-1}$ | quad.$^{-1}$ | $10^{-9}$ | *diopter* | $10^{-2}$ | cm.$^{-1}$ | 1 |
| | *Electric* | | | | | | | | |
| 22 | Electromotive Force | $E$ | abvolt | *volt* | $10^8$ | *volt* | $10^8$ | *volt* | $10^8$ |
| 23 | El: field intensity | $e$ | abvolt/cm. | volt/quad. | $10^{-1}$ | volt/m. | $10^{-2}$ | volt/cm. | $10^8$ |
| 24 | Resistance | $R$ | abohm | *ohm* | $10^9$ | *ohm* | $10^9$ | *ohm* | $10^9$ |
| 25 | Resistivity | $\rho$ | abohm-cm. | ohm-quad. | $10^{18}$ | ohm-m. | $10^{11}$ | ohm-cm. | $10^9$ |
| 26 | Current | $I$ | abampere | *ampere* | $10^{-1}$ | *ampere* | $10^{-1}$ | *ampere* | $10^{-1}$ |
| 27 | Current density | $i$ | abamp/cm.$^2$ | amp./sq. quad. | $10^{-19}$ | amp./sq. m. | $10^{-5}$ | amp./sq. cm. | $10^{-1}$ |
| 28 | Conductance | $G$ | abmho | mho | $10^{-9}$ | mho | $10^{-9}$ | mho | $10^{-9}$ |
| 29 | Conductivity | $\gamma$ | abmho/cm. | mho/quad. | $10^{-18}$ | mho/m. | $10^{-11}$ | mho/cm. | $10^{-9}$ |
| 30 | El: Quantity | $Q$ | abcoulomb | *coulomb* | $10^{-1}$ | *coulomb* | $10^{-1}$ | *coulomb* | $10^{-1}$ |
| 31 | El: Displacement | $D$ | abcoulomb/cm.$^2$ | coulomb/quad.$^2$ | $10^{-19}$ | coulomb/m.$^2$ | $10^{-5}$ | coulomb/cm.$^2$ | $10^{-1}$ |
| 32 | Capacitance | $C$ | abfarad | *farad* | $10^{-9}$ | *farad* | $10^{-9}$ | *farad* | $10^{-9}$ |
| 33 | Permittivity | $\kappa_0$ | (abfarad/cm.) = 1 | farad/quad. = | $\frac{1}{4\pi v^2}$ | farad/m. = | $\frac{10^7}{4\pi v^2}$ | farad/cm. = | $\frac{10^9}{4\pi v^2}$ |
| 34 | Frequency | $f$ | cycle/sec. | cycle/sec. | 1 | cycle/sec. | 1 | cycle/sec. | 1 |
| | *Magnetic* | | | | | | | | |
| 35 | Magnetomotive Force | $\mathfrak{F}$ | gilbert | *amp.-turn* | $\frac{4\pi}{10}$ | *amp.-turn* | $\frac{4\pi}{10}$ | *amp.-turn* | $\frac{4\pi}{10}$ |
| 36 | Mag: field intensity | $H$ | gilbert/cm. | amp-turn/quad. | $4\pi/10^{10}$ | amp-turn/m. | $4\pi/10^3$ | amp-turn/cm. | $4\pi/10$ |
| 37 | Space Permeability | $\mu_0$ | abhenry/cm. | henry/quad. | $1/4\pi$ | henry/m. | $10^7/4\pi$ | henry/cm. | $10^9/4\pi$ |
| 38 | Magnetic Flux | $\phi$ | *maxwell* | volt-second | $10^8$ | volt-second | $10^8$ | volt-second | $10^8$ |
| 39 | Mag. Flux Density | $B$ | maxwell/cm.$^2$ | volt-sec./quad.$^2$ | $10^{-10}$ | volt-sec./m.$^2$ | $10^4$ | volt-sec./cm.$^2$ | $10^8$ |
| 40 | Permeance | $\mathcal{P}$ | (oersted)$^{-1}$ | henry | $10^9/4\pi$ | henry | $10^9/4\pi$ | henry | $10^9/4\pi$ |
| 41 | Reluctance | $\mathcal{R}$ | oersted | yrneh | $4\pi/10^9$ | yrneh | $4\pi/10^9$ | yrneh | $4\pi/10^9$ |
| 42 | Inductance | $L$ | abhenry | *henry* | $10^9$ | *henry* | $10^9$ | *henry* | $10^9$ |
| 43 | Magnetization | $I$ | | volt-sec./quad.$^2$ | $10^{-10}/4\pi$ | volt-sec./m.$^2$ | $10^4/4\pi$ | volt-sec./cm.$^2$ | $10^8/4\pi$ |
| 44 | Magnetic Pole | $m$ | maxwell/$4\pi$ | volt-sec. | $10^8 \times 4\pi$ | volt-sec. | $10^8 \times 4\pi$ | volt-sec. | $10^8 \times 4\pi$ |

It will be observed that all three "practical" systems have the following electric, magnetic, and energetic in common: the *joule, watt, volt, ohm, ampere, coulomb, henry, and ampere-turn*, if the last named may be properly regarded as an international unit. In many of the other units, however, characteristic differences of magnitude appear. Since, owing to the very awkward values of its length and mass units, it is unlikely that anyone will recommend the Q. E. S. system for practical use

throughout, we may confine attention to the M. K. S. Ω and C. G. S. S. systems, in Columns VII and IX.

Among the electric and magnetic units, 22 to 44 inclusive, there is not much to choose between the two systems of Columns VII and IX. Indeed, electrical workers may prefer the centimetric values of Col. IX to the metric values of Col. VII, because by long familiarity with the fundamental C. G. S. system, the centimetric operations are familiar. There is likewise little advantage on either side in the thermal and luminous lists. The principal differences are found in the mechanic series, particularly in Mass and in Density, Nos. 2 and 6. Here the M. K. S. Ω system has distinct advantages. The unit mass of ten metric tons, or $10^7$ grams, is a serious handicap to the C. G. S. S. system. Consequently, if the "practical" system were restricted entirely to the use of electrical workers, with problems involving mass seldom presenting themselves, either of the two systems might be adopted to the ultimate exclusion of the fundamental C. G. S. system. There might then be two remaining systems in scientific work,—one the "practical" system for electrical workers and the other the C. G. S. system for non-electrical workers or all other scientists. It seems more likely that the M. K. S. Ω system would gain the favor of all the non-electrical workers than the C. G. S. S. system with its large unitary mass. In other words, the greater hope for a final single scientific system of units in the distant future seems to lie on the side of the M. K. S. Ω system. At all events, this question deserves careful consideration before a "practical" unit of magnetic intensity $H$, or flux density $B$ is internationally adopted.

*Table III* presents the numerical values of $\kappa_0$ and $\mu_0$ in the three "practical" systems.

TABLE III

NUMERICAL VALUES OF SPACE PERMITTIVITY $\kappa_0$ AND OF SPACE PERMEABILITY $\mu_0$ IN THE Q. E. S., M. K. S. Ω, AND C. G. S. S. "PRACTICAL" SYSTEMS

| * | $n = 9$ $m = -11$<br>Q. E. S.<br>Maxwell, 1881 | $n = 2$ $m = 3$<br>M. K. S. Ω<br>Giorgi, 1901 | $n = 0$ $m = 7$<br>C. G. S. S. or "International"<br>Dellinger-Bennett |
|---|---|---|---|
| Space Permittivity $\kappa_0$ | $\frac{1}{4\pi v^2}$<br>with $v = 29.98$<br>$8.85 \times 10^{-5}$ | $\frac{10^7}{4\pi v^2}$<br>with $v = 2.998 \times 10^8$<br>$8.85 \times 10^{-12}$ | $\frac{10^9}{4\pi v^2}$<br>with $v = 2.998 \times 10^{10}$<br>$8.85 \times 10^{-14}$ |
| Space Permeability $\mu_0$ | $4\pi$<br>12.566 | $4\pi \times 10^{-7}$<br>$1.2566 \times 10^{-6}$ | $4\pi \times 10^{-9}$<br>$1.2566 \times 10^{-8}$ |

*All of the "practical" units thus far (1929) adopted internationally conform to any one of a theoretically infinite series of $LM$ ($T = 1$ sec.) systems, in which $L = 10^n$ cm., and $M = 10^m$ g.; such that $2n + m = 7$. The adoption of the "volt-second" practical unit of flux does not affect this generalization. It seems, however, that the international adoption of a corresponding "practical" unit for either $H$ or $B$ will logically select the particular "practical" system, as M. K. S. Ω or C. G. S. S. for the entire series of Table II, according as the meter or centimeter is taken for length and cross-section.

## Appendix

### Report of International Subcommittee on Magnetic Units

To Doctor C. O. Mailloux, President, I. E. C. Committee on Nomenclature;—

The Subcommittee on Magnetic Units has considered the questions proposed to it at the Bellagio meeting of 1927, as follows:

1. In view of certain differences of usage of the magnetic unit *gauss* in different countries, can we recommend any action directed towards unification of usage in the future?

2. In view of the communication of the Comité Electrotechnique Italien [1 (Italy) 27], presented at Bellagio, what recommendations are we able to make?

The subcommittee has discussed these questions by correspondence only.

The subcommittee recommends (1) that steps should be taken towards unification of the definitions of the magnetic units and of their names. The subcommittee has not yet been able to arrive at an agreement on the specific steps that should be thus taken. It recommends that the Committee on Nomenclature of the I. E. C. should place this important question on the agenda for its next international meeting, and should seek to elicit discussion upon the question in the various national committees, in advance of the meeting, so as to pave the way for well considered international action. (2) The subcommittee is unable to recommend the suggestion in the proposal of the Italian Committee [1 (Italy) 27], to change the name *maxwell* from the C. G. S. U. of magnetic flux $\phi$ to the "practical" or volt-ampere-ohm unit of magnetic flux $\phi$, in view of the dislocation in understanding of electromagnetic literature that might thereby be brought about.

Signed
W. H. Eccles
P. Janet
A. E. Kennelly, Chairman,
L. Lombardi
Mitkievitch
K. Strecker
G. J. Van de Well

24th September, 1929.

Abridgment of

# Dissipation of Heat by Radiation

BY A. D. MOORE[1]
Member, A. I. E. E.

***Synopsis.**—Heat dissipation is an ever-present factor affecting the design and operation of many kinds of electrical equipment. Usually, the problem is to get rid of heat due to losses. Sometimes the problem is how to conserve heat. Radiation, or convection, or conduction, or combinations of these, enter into all cases. Engineering literature as a rule presents conduction and convection in sound terms but in many cases, the treatment of radiation is unsound, misleading, and sometimes in error. This paper is presented with the hope of putting heat radiation in engineering applications on a sounder basis.*

*The usual laws given to cover total heat radiation are stated and discussed, and their limitations brought out. Net heat loss by radiation interchange for the cases of parallel and concentric surfaces are reviewed and stated.*

*The problem of total radiation from a rectangular slot is attacked, the method of solution is indicated by example and discussion, and the results given.*

## Section I

### Introduction

THE term "radiation" has been so thoroughly corrupted by being used to include all forms of heat dissipation, that it needs definition at the outset. Radiation, within this paper, does not include heat dissipation by convection, either natural or forced. It applies only to true radiation, either emitted, reflected, or absorbed by a surface. Radiant heat energy covers the range of the spectrum, including the visible, or light wave energy. Heat waves behave as the more commonly known light waves behave,—they are electromagnetic waves traveling in straight lines; they are reflected by mirror surfaces as light is reflected; a given surface emits, reflects, or absorbs to varying degrees, depending on the character of the surface.

### Stefan's Law of Emission

Stefan formulated the law of radiation emission,

$$R = k\, e\, T^4$$

where $R$ is the rate of heat radiation emission from a unit of surface, $e$ is the emission coefficient for the surface, $k$ is a constant, and $T$ is the temperature in degrees Kelvin (absolute) of the surface.

*Stefan-Boltzmann Law.* When a radiating body is subject to reception of radiation from surroundings radiating bodies, as is usually the case, there is an interchange. The net loss of heat from the body by radiation interchange is perhaps most commonly given in engineering literature in the form of the Stefan-Boltzmann Law,

$$R = S\, k\, e\, (T_1^4 - T_2^{4\prime})$$

in which $R$ represents the net rate of losing heat by the body; $S$ is its surface; $k$ is a constant; $e$ is the emission coefficient for the surface; $T_1$ is the temperature (Kelvin) of the surface, and $T_2$ is variously and loosely described.

Let Fig. 1 represent the body, which has an irregular surface. When the above formula is given, it is usually not stated whether $S$ is to be the actual surface, or the enveloping surface. Usually, nothing is said as to why the surface of the surrounding bodies, and their emission coefficient, are omitted. And $T_2$, depending on the writer, is given as being

1. Temperature of surrounding walls
2. Temperature of surrounding air
3. Temperature of surrounding objects
4. Temperature of surrounding space.

In succeeding articles in this section, an attempt will be made to place radiation interchange, in simple cases, on a more definite basis.

*Black-Body Radiation.* At a given temperature a black-body surface radiates more than any other surface. It radiates the maximum possible amount in all wavelengths, although the energy is distributed over the various wavelengths according to a familiar curve. The black-body is the standard of reference, and its total emission coefficient, $e$, is herein taken as unity. When energy falls on a black-body, none is reflected. Hence, a small window opening into a large black-lined cavity, being a nearly perfect energy trap, is a nearly perfect equivalent of a black-body surface.

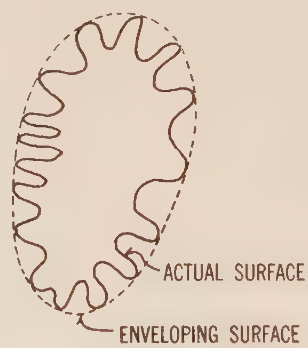

Fig. 1

### Selective Radiation

A given surface may emit selectively; in some wavelengths it may emit (radiate) as much energy as does a black-body, in others, less, and in some, none.

1. Associate Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich.

*Presented at the Great Lakes District Meeting of the A. I. E. E., Chicago, Ill., Dec. 2-4, 1929. Complete copy upon request.*



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### Gray-Body Radiation

If a surface emits so that the energy of all wavelengths is reduced by the same per cent below that which is emitted by a black-body at the same temperature, it is called a gray-body. For example, if its total coefficient is 0.7, it emits seven-tenths as much energy in every wavelength as does the black-body. *In this paper, only black-body and gray-body radiation will be dealt with.* Further, only opaque surfaces will be considered.

### Absorption and Reflection

The absorption ability of a surface depends upon its ability to emit. If it can emit in a given wavelength, it can absorb that wavelength. If it emits completely, as a black-body, it absorbs completely. Incomplete emission, as for a gray-body, is accompanied by incomplete absorption for energy falling upon it. With unity as a base, emission and absorption coefficients are equal. Energy not absorbed is reflected (by opaque surfaces), and the reflection coefficient is $(1 - e)$.

### Prevost's Law of Exchange

By this proposition, radiation emission goes on irrespective of energy that may be absorbed at the same time.

### Stefan's Law Written to Give Watts

Stefan's law of emission is

$$R = S\, e\, 36.9 \left( \frac{T}{1000} \right)^4$$

where $R$ is watts, $S$ is the surface in square inches, $e$ is based on unity, and the constant is as given.

It is important to note that this law gives initial emission correctly only if the surface is so disposed that none of it receives radiation from some other part of it, and that it gives only emission; it takes no account of radiation received from other possible bodies in the neighborhood.

### Net Radiation Transfer of Heat for Simple Interchange Cases[2]

(*a*) *Parallel Surfaces.* Two parallel surfaces, of the same extent, are placed so close together that escape from edge openings is negligible. $S_1$ has $e_1$ and $T_1$ for emission coefficient and temperature, respectively, and for $S_2$, like quantities are $e_2$ and $T_2$. The two energies initially emitted by the two surfaces in a given time increment, are inter-reflected, with two infinite series as the result. The net watts lost by $S_1$ will be

$$R = 36.9\ (1000)^{-4}\ S_1\ (T_1^4 - T_2^4)\ \frac{e_1\, e_2}{e_1 + e_2 - e_1\, e_2}$$

(*b*) *Concentric Spheres.* Let $S_1$, $e_1$, and $T_1$ be the surface in square inches, the coefficient, and the temperature, respectively, for the surface of an enclosed sphere, and $S_2$, $e_2$, and $T_2$ like values for the surface of an enclosing spherical wall concentric with the sphere. The net rate of heat loss by $S_1$, in watts, is

$$E = 36.9\ (1000)^{-4}\ (T_1^4\, S_1 - T_2^4\, S_2\, P)\ \frac{e_1\, e_2}{e_1\, P + e_2 - e_1\, e_2\, P}$$

where $P$ is as follows: at any given stage of reflection, when a quantity of heat $H$ leaves the walls, the fraction $P$ is such that $P\,H$ is the part of $H$ that strikes the enclosed sphere. $P$ is determined by the characteristic of the surface, as to what degree heat coming from it is diffused. If we deal with mat surfaces (as described in Section II), the above expression simplifies to

$$R = 36.9(1000)^{-4}\, S_1(T_1^4 - T_2^4)\frac{e_1\, e_2}{e_1 \dfrac{S_1}{S_2} + e_2 - e_1\, e_2 \dfrac{S_1}{S_2}}$$

(*c*) *Concentric Cylinders.* This case, as to symbols and treatment, is similar to the preceding case; and with similar meanings, and mat surfaces, the expression for the watts lost by the enclosed cylinder is the same as the final expression given above.

If, in the concentric cases, the two radii are allowed to approach equality, the cases approach the case of parallel surfaces, physically; and the expression for the concentric cases then degenerates into the expression for parallel surfaces, as it should.

Again, in the concentric cases, if $S_2$ becomes infinite so that the enclosed body is a very small object in a very large room; or if, with infinite dimensions, the coefficient $e_2$ of the enclosing wall is made unity (black-body), the expression degenerates into the Stefan-Boltzmann law. Thus the Stefan-Boltzmann law is correct only under one or the other of the two conditions specified at the beginning of this paragraph.

## Section II

## THE SLOT

### Convolutions

When a body is corrugated, like a transformer tank, or when it is slotted, or when cooling fins are attached to it,—is its radiating ability increased, or is its radiation, effectively, determined by its enveloping surface? Probably the simplest ideal set-up for answering this question is to compare the total radiation of a slot with the radiation from an undisturbed portion of surface that would just cover the slot mouth.

### The Mat Surface

Underlying the development of the concentric cases of Section I, and all of the work in this section, is the assumption of the mat surface. The mat surface is a diffusing surface, both for radiation it may emit, or for that which it may reflect. It obeys the cosine law. Imagine a small increment of such a surface, and erect on its plane a hemisphere with the area at its center. Radiation from the area is most intense through the

2. The full development for the cases is given in "Fundamentals of Electrical Design," A. D. Moore, McGraw-Hill.

spherical shell along the normal radius; call this intensity, $I$. Then the intensity at the shell for any other radius is $I \cos \theta$, where $\theta$ is the angle between the selected radius and the normal radius. This is equivalent to saying that for the mat surface, the intensity in watts per square inch at the point of view is proportional to the projected area as viewed from that position, all positions being at the same radius.

### The Slot

The paper from here is concerned with finding the total radiation per unit length from a rectangular slot that is infinitely long, 2 in. wide, and 8 in. deep. The solution method is semi-mathematical. The entire slot surface is divided into strips of equal width (1 in.),

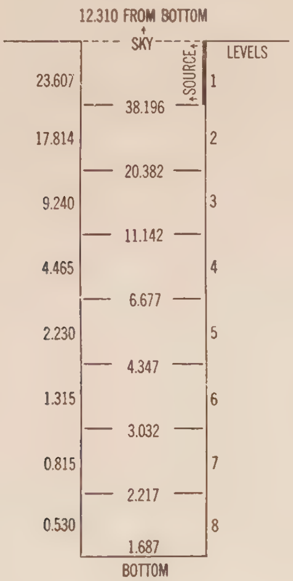


Fig. 2

and accurate "interchange" values are found mathematically.

Fig. 2 shows the slot. Let the strip shown as Level 1 emit uniformly 100 watts per sq. in. Then, by simple mathematical processes not given here, the values to the left of the slot were found. For example, the top value is 23.607, which means that of the 100 watts sent out by the right strip, Level 1, the opposite or left strip, Level 1, receives 23.607 watts; and strips at other levels receive less amounts. From these values it is a simple matter of argument and arithmetic to obtain all other values given in Fig. 2.

For example, the figure shows that if a floor were placed 1 in. down the slot, it would receive, out of 100 watts leaving Level 1 strip (at one side only) 38.196 watts; and the true bottom would receive 1.678, as shown.

### Principle of Reciprocity

Suppose a surface of any size, $S_1$, being a uniformly dense source of 100 watts per unit area, sends a total of $W$ watts to another surface of any size, $S_2$. Then if $S_2$ is made a uniformly dense source of 100 watts per unit area, it will send the same, or $W$, watts, to $S_1$. This principle is too well known to prove here, and anyone unfamiliar with it can easily verify it by study of simple cases.

This principle at once gives a double meaning to every value shown on Fig. 2. For example, the interchange value connecting a strip in Level 1, and the entire bottom, which is two strips wide, is 1.687, the meaning of which, in one direction, was given above. In reverse, or by reciprocity, if the bottom is a uniform source of 100 watts per sq. in., it will send to the strip in Level 1, 1.687 watts per sq. in.

Fig. 2 thus gives interchange values between any wall strip and any strip in the opposite wall, and between any wall strip and the bottom. It also gives 12.310 as the interchange between bottom and sky opening, a value easily obtained once the other values were established. All values given on Fig. 2 are, it is believed, correct to one-tenth of one per cent.

### Method of Attack

Note: The paper is here abridged by the omission of four articles covering Method of Attack; First Stage; Self-Repeating Distribution and Summation; and Procedure for Coefficient other than Zero.

### Effective Emission Coefficients for Enveloping Surface

In the case just carried through, for an actual $e$ of 0.1, the enveloping surface (slot mouth area) was found to have an effective, $e'$, of 0.446. This means that if a surface of this kind, being originally flat, is improved by putting on fins to make the surface "all slots" of the 2 x 8 size, its total radiation would be increased over four times, $e$ being 0.1, and surface temperature being everywhere constant.

Fig. 3 shows the relation of $e'$ to $e$ for this slot proportion over the entire range. Ordinates to the curve are believed to have no errors greater than 4 per cent. The points placed in small circles were computed as in the preceding work.

### Conclusions

Stefan's law of emission holds only for non-interfering surfaces. Where corrugations, convolutions, slots or fins occur, an effective coefficient used in connection with the enveloping surface must be used.

If the surface is a black-body to begin with, radiation is not increased by slotting or finning it; but if $e$ is unavoidably low, considerable benefit may be derived.

It is probable that cooling fins have been added to hot bodies primarily with the idea of increasing dissipation by convection. The above study shows that in a vacuum tube, for example, where convection cooling may be negligible, a hot member made, of necessity, of a metal having a low coefficient, may be considerably assisted in radiating heat by adding fins.

Abridgment of

# Effects of Electric Shock

BY W. B. KOUWENHOVEN[1] and ORTHELLO R. LANGWORTHY[2]

Member; A. I. E. E. Non-member

***Synopsis.***—*This paper describes an investigation of the effects of electric shock on the central nervous system. A total of 286 rats was employed in the investigation. These were shocked at 110, 220, 500, and 1000 volts on both alternating- and continuous-current circuits for varying lengths of time. In each series the duration of the shock was increased until it was found impossible to resuscitate the rats. When possible, the rats were resuscitated by means of artificial respiration and kept alive for about a week. Then they were killed by an overdose of ether and an autopsy was immediately made.*

*The rats reacted in entirely different manner on the two types of circuit; at the lower voltages the alternating current was deadlier than the continuous, but at the high voltage, the opposite was found to be the case.*

*In many instances the rats were paralyzed by the application of the current and at autopsy in the majority of these animals gross hemorrhages were found in the spinal cord. All of the deaths that occurred as a result of the shock were caused by respiratory failure, which usually could be traced to an injury of the central nervous system. In some cases the electric current produced peculiar effects upon the rats.*

* * * * *

*General.* The first death from contact with an electric circuit occurred in France in 1879. As the use of electricity has become prevalent, the number of accidents has increased. In the United States approximately 50 per cent of the accidents are fatal and the death rate from electricity is 0.9 per 100,000 population.

In the case of an electric accident, there are five factors that are of importance; namely, (1) the voltage of the circuit; (2) the current that flows through the body; (3) the duration of the contact; (4) the type of circuit, direct or alternating, and the frequency; and (5) the points on the body where contact is made with the circuit.

*Voltage.* It is a well recognized fact that high-voltage circuits are dangerous. Low voltages also are dangerous and especially so when the victims contact with the circuit is good. Recent data seem to indicate an increase in the number of deaths caused by contact with low-voltage circuits used in residences. No authentic record has been found, however, of a death on a 110-volt d-c. circuit.

On high-voltage circuits the victim is often thrown away from the conductors by the severe contraction of the muscles, but on low-voltage circuits it is often impossible to let go. It is interesting to note that approximately one-third of the fatal accidents reported occur on low-voltage circuits.

*Current.* The current that will flow in any given case depends not only upon the system voltage but also upon the resistance offered by the body. This lies mainly in the skin, which when in a dry state has a resistance of from 40,000 to 100,000 ohms per sq. cm. In a thoroughly wet condition, however, the resistance of the skin contact falls as low as 1000 ohms per sq. cm.

The sensation produced by an alternating current of 15 to 20 milliamperes is extremely painful and a current of 100 milliamperes may cause death. Therefore, it is evident that if the skin of the victim is wet, 110-volt a-c. circuits are dangerous.

The resistance of the body decreases also if contact is made with the circuit for any length of time. In our tests, if the animal was allowed to remain in the circuit for any length of time, the current increased from 5 to 10 per cent.

*Duration of Contact.* The possibility of successful resuscitation decreases rapidly as the time of contact with the circuit increases. The higher the voltage of the circuit, the shorter the time that a man can remain in contact with it and still be resuscitated.

*Type of Circuit.* Low-voltage a-c. systems of commercial frequency are more dangerous than continuous-current circuits of the same voltage. A continuous current produced electrolysis of the body fluids and some strong contractions of the muscles. Alternating current, on the other hand, produces no electrolysis but a very severe contraction of the muscles.

*Position of the Electrodes.* If the contact of the body with the circuit occurs at points so located that the current does not pass through any vital organ, as a rule no permanent damage will result.

*Experimental Study.* The purpose of this investigation was to determine the effect of electric shock upon the central nervous system, to study the behavior of shocked animals, to ascertain if possible the cause of deaths due to respiratory failure, and to find how many cases of delayed deaths are the result of demonstrable lesions in the central nervous system.

Rats were chosen because they are easy to transport and inexpensive. The heart of the rat also recovers spontaneously from the uncoordinated contractions called fibrilation, produced by the passage of the current. No deaths in these tests were due to heart failure.

The effect on rats of alternating 60-cycle and continuous currents at constant potentials of 110, 220, 500 and 1000 volts for varying lengths of time was studied. The authors felt that the changes in the nerve cells could be seen especially clearly if the animal was re-

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*Complete copy upon request.*

suscitated after the shock and allowed to live several days. This procedure was carried out; the rat was then killed and the central nervous system examined at once. Attention was confined mainly to a study of the effects produced by the electric current on the spinal cord and brain.

It must be remembered that the results obtained from a study of one experimental animal cannot be applied directly to a consideration of other animals, or man.

*Technique.* While the animal was being given ether, the voltage was adjusted to the desired value for the test. As soon as the rat was anesthetized, after wetting the skin with a saturated salt solution the electrodes were attached. One electrode was fastened to the base of the tail, and the other electrode placed on the skull. The electrode used on the skull was made especially for the work and was held in place by springs that pressed against the lower jaw, in no way obstructing the breathing. The electrode proper was 1.2 cm. in diameter and was insulated from the springs so that all of the current passed through the top of the head.

In the majority of tests, electrodes as described above were applied on the head and tail of the rat. Another group of observations were made with one electrode on the head and the other on one of the fore legs; also with one electrode on one fore leg and the other on the opposite hind leg. The results obtained were similar and apparently entirely independent of the electrode positions.

After the electrodes were in position, the animal was watched closely until it showed signs of initial recovery from the ether; then the high-voltage switch was closed for the proper length of time. Immediately following the opening of the circuit, the electrodes were removed from the animal and artificial respiration was applied. If possible, the rat was resuscitated and allowed to live for three or four days. It was then killed and an autopsy performed at once.

The resuscitation method used was as similar as possible to the Schaefer prone-pressure method used for man. Every effort was made to save the rat and often artificial respiration was continued for 10 or 15 min. Upon such animals as died under shock, and those which could not be induced to breathe, autopsies were performed at once.

The circuit was held closed for varying lengths of time, the shortest interval, called instantaneous time, being just sufficient to close and open the switch. Suitable instruments to measure the current that passed through the animal were used; the duration of the shock was measured by means of a stop watch. In making the tests at any given voltage, a shock of short duration was used for the first experiments and gradually increased until it was no longer possible to resuscitate the animal.

*Observations.* In all, 286 rats were shocked, and the observations are grouped according to the voltage and type of circuit used.

*110-Volt Alternating Series.* Eleven rats were shocked at this potential, with the time of contact varied from 10 to 30 secs. Of the eleven rats of this series, seven (64 per cent) recovered; three (27 per cent) died; and one (9 per cent) was paralyzed. When the paralyzed rat was examined, blood was found in the urine and a large hemorrhage in the spinal cord. Hemorrhages of this type were frequently found as a result of the shock.

Artificial respiration was used on all but one of the rats. Their recovery was slow and from a few minutes to half an hour following the shock, they lay quiet. They were inactive for the first 24 hours, neither eating nor drinking. After that period they became apparently normal.

One of the rats that recovered died three hours later, and upon autopsy was found to have a large hemorrhage in the spinal cord. One of the three rats that died at once was found to have a hemorrhage in the cord, but the other two showed no gross abnormalities.

Of the six rats that recovered and continued to live until killed, five were found to be normal and one showed a hemorrhage in the brain.

Three of the rats that were in the circuit for some time breathed spontaneously while the circuit was closed. They all, however, ceased to breathe when the circuit was opened. Two were saved by artificial respiration, but the third never breathed again, although the heart was strong.

Two of the rats that recovered had spasms of the muscles, and in two cases bleeding from the nose was evident.

*220-Volt Alternating Series.* Twenty-nine rats were shocked at this voltage; the time of contact varied from 5 to 35 secs. Of the twenty-nine tested, eight (28 per cent) recovered; eleven (34 per cent) died; and ten (38 per cent) were paralyzed. The ten that were paralyzed became incontinent (could not control the bladder). All showed blood in the urine, and all showed typical hemorrhages in the spinal cord.

It was necessary to use artificial respiration on all but two of the rats. Their recovery was slow and their breathing was shallow, labored, and irregular.

Seven of the rats that died started to breathe with artificial respiration, but the breathing was not maintained and they died despite efforts to save them. In the case of all of the rats that were held in the circuit for several seconds, there was an increase in current with time.

Of the eleven rats that died, three showed a developing hemorrhage in the spinal cord and one a hemorrhage in the brain; the others were normal so far as could be detected at autopsy. One of the eight that recovered showed a slight hemorrhage in the cord.

An interesting point is brought out by the results of a 14-sec. shock; the two rats that recovered from this shock were both very large. It was found that the small rats succumb much more easily to electric shock

than the larger animals. It is believed that this is due to the lower current density in the vital organs of the larger animals.

No differences were found between the death rates of the two sexes.

Twenty-two of the rats used in this series bled from the nose or eyes. One peculiar phenomenon for which no explanation is known is that in case of bleeding from the eyes, the right eye bled more often than the left. In the case of one of the males there was an ejaculation.

The percentage of rats that was permanently injured or died on the 220-volt circuit was 72. This greater percentage of injuries in combination with the short time of application indicates clearly that 220 volts is much more deadly to rats than 110 volts.

*500-Volt A-c. Series.* Twenty-six rats were shocked at this voltage; the time of contact was varied from one to four seconds. Of the twenty-six tested, ten (38 per cent) recovered; three (12 per cent) died; and thirteen (50 per cent) were paralyzed. All of the paralyzed rats except one showed the typical hemorrhage in the spinal cord.

A number of rats on this circuit recovered spontaneously after the circuit was opened. As the time of the contact was increased, artificial respiration became necessary. The contraction of the muscles upon the closing of the circuit was very great; the legs were stiffly extended and the contraction persisted for several seconds after opening the circuit. There were clonic movements and tremors following the opening of the circuit. Following the shock, 18 of the animals bled from the nose or eyes.

Not a single animal survived a four-second application without permanent injury. In the paralyzed rats that were examined, the typical hemorrhage in the spinal cord was found in all except one. In one of the three that died, the surface of the cortex was found to be seared; in another, there was a hemorrhage in the brain. One was apparently normal.

There was some burning at the points where the electrodes were fastened to the animal in four of the rats. Bleeding from eyes or nose, or both, was observed in 18 cases, and in three of the rats there was a discharge of bloody fluid from the mouth. Ejaculation was noticed in the case of four of the six males that were shocked for periods of three and four seconds. In one of the 10 rats that recovered there was a slight hemorrhage in the brain; the others appeared normal.

This series also clearly demonstrated that there is no difference between the susceptibility of the sexes to electric shock. It is evident that an application of 500 volts is much more injurious than the lower voltages; with a maximum time of application of four seconds, 62 per cent of the animals were paralyzed or died.

*1000-Volt Alternating Series.* For periods varying from one to four seconds, twenty-eight rats were subjected to a potential of 1000 volts. Of those tested, eight (29 per cent) recovered; nine (32 per cent) died; and eleven (39 per cent) were paralyzed. The ten that were paralyzed all became incontinent, blood was found in the urine, and all except one showed the typical spinal hemorrhage.

It was necessary to use artificial respiration on nearly every rat and in many cases considerable effort for a prolonged period was required to save the animals. In some cases breathing was started by means of artificial respiration, only to stop again; then artificial respiration had to be applied anew. In a few cases it was necessary to watch the animals for half an hour or more. Some died despite every effort. In those that lived the breathing was shallow, irregular, and labored.

The contraction of the muscles was very great and it existed for several seconds after the circuit was opened. Clonic movements and tremors also followed the opening of the circuit. Many of the rats exhibited spasmodic contractions of the muscles of mastication; twelve bled from the nose or eyes or both.

Of the nine rats that died, seven showed injuries to the spinal cord or brain and two were apparently normal. It was possible to start respirations in several of these animals, but breathing could not be maintained. In all nine cases the heart beat strongly after the shock.

There was severe burning at the electrode contact and several of the rats that recovered subsequently showed severe injuries from this cause.

Many of the rats used in this series were of large size. This, to some extent, accounts for the fact that there was not a greater mortality. The results show that 71 per cent died or were paralyzed.

*110-Volt Continuous Series.* Thirty-three rats were subjected to this voltage; the duration of the shock varied from 5 to 60 sec. Of the number observed, twenty-eight (85 per cent) recovered; four (12 per cent) died and one (3 per cent) was paralyzed. The paralyzed rat showed the typical hemorrhage in the spinal cord which was so commonly found in rats shocked on a-c. circuits.

During the passage of the current, the contraction of the muscles was not so great as on an a-c. circuit of the same voltage. During long time applications the current increased as it did in the alternating cases, and during the passage of the current there were clonic contractions of the muscles. No artificial respiration was needed in the case of those rats which were held in circuit less than 20 secs.; they started to breathe spontaneously. If the rat was held in the circuit for more than 20 sec. it began to breathe while the current was still flowing. When the circuit was opened, breathing stopped and it was usually necessary to apply artificial respiration to start the animal breathing again. The rats recovered promptly and were active sooner than those which had been given a shock with 110-volt alternating current. In this series there was no evidence of bleeding.

One of the four rats that succumbed to the shock was found to have a hemorrhage in the brain; the other

three showed no abnormalities at autopsy. In one of the rats that recovered, a hemorrhage was found in the brain; the others examined were normal. In all cases the heart beat well following the shock.

Only 15 per cent of the rats tested on a 110-volt continuous circuit were injured or died, although the duration of the shock was considerably longer than in the 110-volt alternating series.

*220-Volt Continuous Series.* Nineteen rats were shocked at 220 volts, continuous potential; the duration of the shock varied from 5 to 30 secs. Of the rats tested at this voltage, ten (53 per cent) recovered; eight (42 per cent) died; and one (5 per cent) was paralyzed. On examination after death, in the paralyzed rat no sign of any gross abnormality could be detected.

In this group it was again noted that the muscular contraction was less than on an alternating circuit; the animals were more relaxed after the shock. Clonic movements were present in all of these rats both during and immediately after the shock. It was necessary to use artificial respiration on all but four of the rats in this series, and none of them breathed while in the circuit. No bleeding was noticed in this series.

Of the eight rats that died, one was found to have a hemorrhage in the brain; the others that were examined were normal. None of the rats that recovered showed abnormalities in either the spinal cord or brain. In this series 47 per cent of the rats died or were injured.

*500-Volt Continuous Series.* Thirty-seven rats were shocked at this voltage, the duration of the shock varied from one to four seconds. Eighteen (49 per cent) of the thirty-seven recovered; seventeen (46 per cent) died; and two (5 per cent) were paralyzed. In the two paralyzed rats at autopsy no trace of hemorrhage in the nervous system could be found.

The contraction of the body musculature was not so severe as on an alternating circuit. Clonic movements were noticed both while the current was flowing and after the circuit was opened. Artificial respiration was needed in all except five cases and for four or five minutes after the shock in all of the rats the heart beat well. Five of these rats had convulsions following the shock and showed increased and abnormal responses to all stimuli. This was the only series in which these convulsions were observed. Ten of the animals bled from the nose, eyes, or mouth, and it will be noted that this is the first appearance in the continuous current series of this phenomenon which was so common in the alternating groups.

No apparent injury to the nervous system on gross examination could be detected in any of the eighteen rats that died. Only two of the rats in this series showed hemorrhages in the brain, and these two rats recovered from the shock. All of the recovered rats were normal; their breathing, however, was labored and fast.

This series brings out clearly the effect of the size of the animal upon the experimental results. Eleven rats three months old were given a two-second shock and seven of them died. Of four larger rats under the same duration of shock, two died and two recovered.

There was some burning at the electrodes caused by the current density, but there was no indication of any actual burning of the cerebral cortex.

In this series, 51 per cent of the rats died or were paralyzed as the result of contact with the 500-volt circuit, but the cause of death cannot be ascribed to gross damage to the nervous system.

*1000-Volt D-c. Series.* Thirty-three rats were tested at this voltage; the duration of the shock varied from instantaneous contact to four seconds. No rats, irrespective of size, survived a contact of one second or longer with this circuit. Of the 33 shocked, nine (27 per cent) recovered; twenty (61 per cent) died; and four (12 per cent) were paralyzed. In this series, at autopsy the central nervous system of the paralyzed rats was found to be grossly normal.

These rats showed the clonic movements of the legs which appear to be so characteristic of continuous current shocks. The contraction of the muscles was somewhat greater than with the 500 volts continuous current, but not nearly so great as with the alternating currents.

Breathing was shallow and irregular and those rats that recovered were very disturbed. Artificial respiration was used in every case but one; although the heart beat strongly, it was seldom possible despite the greatest efforts to initiate breathing. The chest of the animals were collapsed following the shock, and no air would enter the lungs. Following the shock four of the animals bled from the nose, eyes, or mouth. After 24 hours, the two paralyzed rats became incontinent, although no blood was found in the urine.

No signs of gross injury to the nervous system could be detected in any of the rats that were used in this series and although there was considerable burning at the electrodes, no damage to the surface of the brain was found. This series is characterized by a high percentage of fatalities and the most prominent feature noted was persistent priarpism (permanent erection) in the males.

*Comparison of the Alternating and Continuous Series.* Exact comparison between the results of shocks with alternating and continuous currents is impossible because the duration of the contact was not the same; the size of the animals differed with corresponding differences in current, and the number of animals varied in the two series. There is also the factor of the relative strength and health of the rats at the time of experimentation,—which it is impossible to ascertain.

On a-c. circuits there was a continuous, severe tetanic contraction of the muscles which usually persisted for a few seconds after opening the circuit. The chest of the animal was greatly expanded and the shock was usually followed by clonic movement of the legs. A large number of rats were subsequently found to be paralyzed in the hind legs and in these a hemorrhage was present

in the spinal cord. Bleeding from the eyes or nose occurred in many of the animals.

On continuous current circuit the contraction of the muscles was not so severe as on the alternating circuit, and clonic movements were usually present while the current was flowing. Relatively few of the animals were paralyzed and only one of these showed the characteristic hemorrhage in the cord, so common in the alternating series. Few gross injuries could be detected in the central nervous system. Bleeding from the nose was observed at the higher voltages only.

### Conclusions

The following conclusions are drawn from the investigation:

1. The 110- and 220-volt a-c. circuits are more dangerous to rats than the corresponding d-c. circuits.
2. A d-c. circuit of 1000 volts is more dangerous to rats than the corresponding alternating voltage.
3. A large rat can withstand a greater shock than a small one and still survive.
4. The contraction of the body musculature is greater on an alternating voltage than on a d-c. circuit.
5. In many cases the alternating current experiments are characterized by paralysis of the hind legs caused by hemorrhages in the spinal cord.
6. The three different positions of the electrodes investigated produced similar abnormalities.
7. A severe electric shock probably produces changes in the nervous system that are incompatible with life.
8. The death of the rats that could not be resuscitated was due in every case to respiratory failure.
9. The death of rats that lived for only a few hours after the shock was found to be caused by hemorrhages in the brain.
10. The injuries are not directly proportional to the amount of current that passes through the body. Not only is the initial voltage of importance, but the duration of the contact and the size of the animal also.

It must be kept in mind that these results cannot be applied directly to men or to other animals.

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Abridgment of

# Polyphase Induction Motors

## A Labor Saving Method of Calculating Performance from Previously Determined Constants

BY W. J. BRANSON[1]

Associate, A. I. E. E.

*Synopsis.—This paper presents a method of calculating polyphase induction motor performance which eliminates a large amount of detail work without making use of approximations which sacrifice accuracy. In any rigorous system for calculating induction motor performance, the determination of the relation between input and current values makes the greater part of the work.*

*By the procedure here presented, the relation of watts to amperes for all cases likely to be encountered in ordinary design work may be accurately calculated once for all and recorded in a set of curves. When making practical calculations tedious detail work may be eliminated by taking the necessary values from the curves, in much the same way that sines are taken from sine tables.*

*The calculation begins with the torque, from which the corresponding secondary input is obtained by a simple formula. Then, by reference to the appropriate curves and a few simple slide rule operations, the primary and secondary currents are determined. With the secondary input and the current values known, the completion of the calculation requires nothing more than a few operations of simple arithmetic. The entire process for one load point may be completed in from five to seven minutes.*

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### I. Introduction

The methods most frequently used in calculating the performance of polyphase induction motors are:

1. The Steinmetz analytical equations based on the "exact equivalent circuit."
2. The various forms of the circle diagram.

With the exception of a slightly unscientific treatment of core losses, the Steinmetz equations are rigorously correct mathematical processes, but they require a large amount of detail work. Using ordinary facilities, the time required to calculate the output, revolutions per minute, efficiency, power factor, etc., for a single load point is usually about 40 or 45 min.

If properly constructed, the circle diagram also constitutes a rigorous mathematical process, but the forms commonly used and presented in text books are based on approximations which sacrifice accuracy while still requiring a very objectionable amount of labor.

### II. General Character of the Process

This paper presents a method of procedure by which it is possible to complete an accurate performance calculation in from 5 to 7 min.—that is, in about one-sixth of the time required by the Steinmetz equations. The processes which eliminate so much detail work

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are somewhat analogous to the use of tables of trigonometric functions. If trigonometric tables did not exist, the easiest way to obtain the sine of an angle would be to construct an appropriate triangle and divide the side opposite the angle by the hypotenuse. Anyone who had occasion to do this frequently, however, would naturally discover that by constructing, once for all, a series of triangles, he could draw a curve from which the sine of any angle might be read directly.

In a similar manner, it is possible to make curves showing any desired geometrical relations of the circle diagram corresponding to all possible combinations of motor constants; and, with properly constructed curves of this character available, a performance calculation for an ordinary polyphase motor requires no

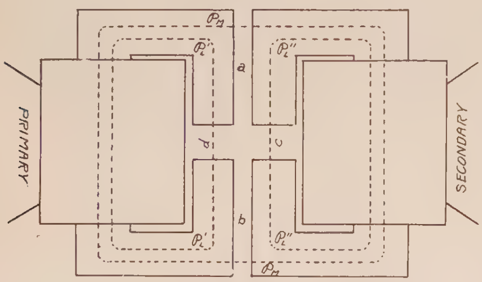



Fig. 2—The Flux Paths of a Transformer with an Air-Gap and Large Magnetic Leakage

detail work beyond reading the necessary values from the curves and carrying out a few simple arithmetical operations.

## V. The Transformer

Fig. 2 shows a transformer with magnetizing and leakage characteristics similar to those of an induction motor. The broken lines represent flux paths.

$\mathcal{P}_m$ = Permeance of the path through both coils
$\mathcal{P}_{\mathrm{I}}'$ = Permeance of the primary leakage path
$\mathcal{P}_L''$ = Permeance of the secondary leakage path.

The most important of the fundamental constants which determine the performance of a transformer or an induction motor may be expressed as ratios between the permeance values.

$$\text{The primary flux factor } K_p = \frac{\mathcal{P}_m}{\mathcal{P}_m + \mathcal{P}_L'}$$

$$\text{The secondary flux factor } K_s = \frac{\mathcal{P}_m}{\mathcal{P}_m + \mathcal{P}_L''}$$

## VI. Reactance

The reactance of a transformer represents the ratio of inductive drop to amperes just as resistance represents the ratio of resistance drop to amperes. In a circuit containing only resistance, the current

$$I = \frac{E}{R}$$

while in a circuit which has reactance without resistance,

$$I = \frac{E}{X}$$

Since the induced e. m. f.

$$E = 2\,\pi\, f\, N^2\, 10^{-8}\, \mathcal{P}\, I$$

we may derive the fundamental equation for reactance as follows:

$$I = \frac{2\,\pi\, f\, N^2\, 10^{-8}\, \mathcal{P}\, I}{X}$$

and

$$X = 2\,\pi\, f\, N^2\, 10^{-8} \times \mathcal{P}$$

It is convenient and helpful to think of this expression for reactance as made up of the two main factors which are separated by a multiplication sign. The combination of symbols on the left, $2\,\pi\, f\, N^2\, 10^{-8}$, will be found in exactly the same form in all of the equations which appear in the list below, while the characters which stand for permeance take a special form in each equation and determine the significance of the various reactances.

*Reactance Values Used in this Paper.*

Reactance of primary with secondary open.

$$X_o' = 2\,\pi\, f\, N^2\, 10^{-8}\, (\mathcal{P}_m + \mathcal{P}_L')$$

Reactance of secondary with primary open.

$$X_o'' = 2\,\pi\, f\, N^2\, 10^{-8}\, (\mathcal{P}_m + \mathcal{P}_L'')$$

Reactance of primary with secondary short-circuited.

$$X_{sc}' = 2\,\pi\, f\, N^2\, 10^{-8}\, (\mathcal{P}_L' + \mathcal{P}_L''\, K_s)$$

Reactance of secondary with primary short-circuited.

$$X_{sc}'' = 2\,\pi\, f\, N^2\, 10^{-8}\, (\mathcal{P}_L'' + \mathcal{P}_L'\, K_p)$$

In practical work it is usually assumed that $\mathcal{P}_L' = \mathcal{P}_L''$ and consequently that

$$K_p = K_s$$
$$X_o' = X_o'' = X_o$$
$$X_{sc}' = X_{sc}'' = X$$

A series of diagrams showing the flux paths corresponding to all of the reactance values listed above will be found in Figs. 6 to 9.

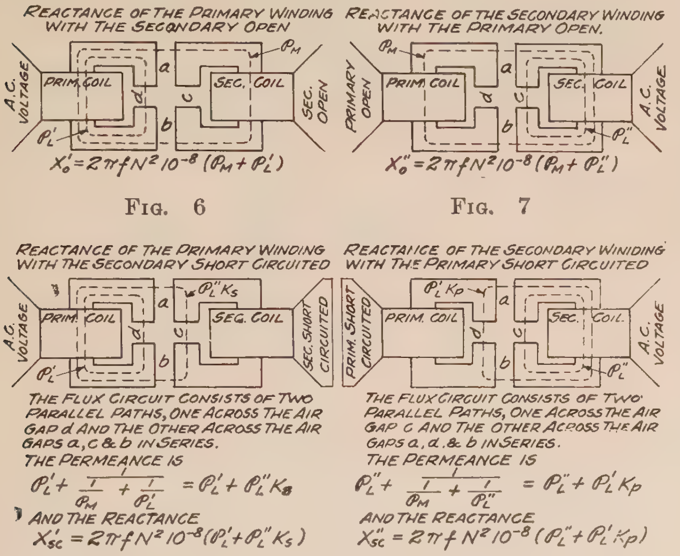
## VII. Circle Diagram

The development of a mathematically exact form of the circle diagram may be traced through Figs. 10, 11, 12, and 13. These figures are so constructed and arranged as to show successively the effects of the various constants. In Figs. 10 and 11 the motor is assumed to have reactance without resistance or iron loss. Fig. 12 shows the modifying effects of secondary resistance while Fig. 13 shows the modifying effects of primary resistance and core losses.

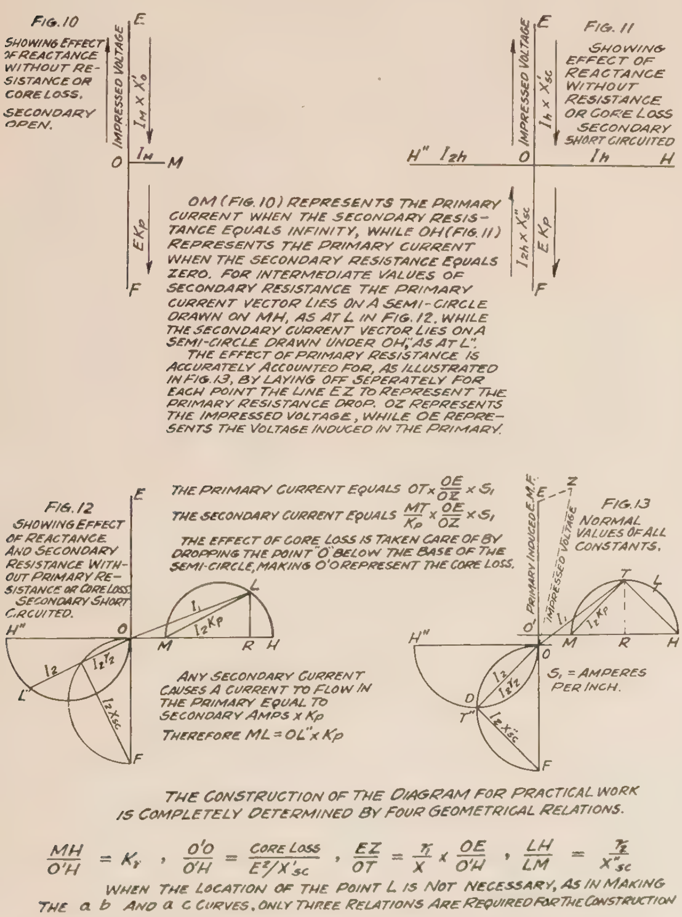
Fig. 15 shows a practical working diagram and is similar to the upper right hand portion of Fig. 13 except that the primary resistance drop is represented by an extension of the current vector instead of a separate parallel line. The complete procedure for making

calculations by this diagram is given on the work sheet. Fig. 15.

This work sheet is introduced to show how the circle diagram may be used in a correct form for practical calculations and also to illustrate the general method of procedure which underlies the much easier process explained in the next section.



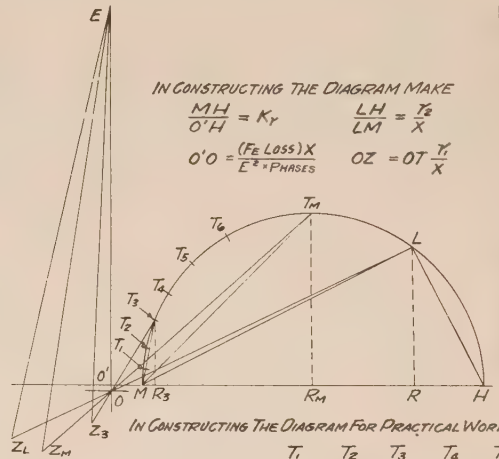

FIGS. 6-9—REACTANCE VALUES USED IN THE SYSTEM PRESENTED IN THIS PAPER




FIGS. 10-13—DEVELOPMENT OF THE CIRCLE DIAGRAM

## VIII. THE BASIS OF THE CURVE METHOD

The outline given below shows a simple and straight forward procedure for the calculation of polyphase induction motor performance without the circle diagram. This process, or something equivalent, would probably be used by all designers if suitable equations were available for the third and fourth steps.




| DATA | | |
|---|---|---|
| PREDETERMINED BY CALCULATION OR TEST | | |
| 1 | E, 2φ = LINE V.<br>E, 3φ = LINE V. ÷ 1.73 | |
| 2 | PHASES | |
| 3 | SYN. SPEED | |
| 4 | $r_1$ (HOT) | |
| 5 | $r_2$ (HOT) MOTOR RUNNING | |
| 6 | $r_2'$ WITH ROTOR LOCKED | |
| 7 | X | |
| 8 | $X_o$ | |
| 9 | FE. LOSS | |
| 10 | F&W LOSS | |
| 11 | $r_1/x$ = (4)/(7) | |
| 12 | $r_2/x$ = (5)/(7) | |
| 13 | $K_r$ = [(8)−(7)]/(8) | |
| 14 | $S_1 = E/10X$ | |
| 15 | $S_2 = S_1/\sqrt{K_r}$ | |

| | | | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_5$ | $T_6$ | $T_M$ | $T_L$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 16 | OT | FROM DIAGRAM | | | | | | | | |
| 17 | MT | " " | | | | | | | | |
| 18 | TR | " " | | | | | | | | |
| 19 | OZ | (11) × (16) | | | | | | | | |
| | COMPLETE THE ABOVE LINES OF EACH COLUMN THEN LAY OFF THE OZ LINES LOCATING THE Z POINTS AND PROCEED | | | | | | | | | |
| 20 | ZE | FROM DIAGRAM | | | | | | | | |
| 21 | OE/ZE | 10/(20) | | | | | | | | |
| 22 | PRIM. AMPS. | (16) × (14) × (21) | | | | | | | | |
| 23 | SEC. AMPS. | (17) × (15) × (21) | | | | | | | | |
| 24 | SEC. INPUT | (18)×(14)×(1)×(2)×(21)² | | | | | | | | |
| 25 | SEC CU. LOSS | (23)² × (2) × (5) | | | | | | | | |
| 26 | SEC. OUTPUT | (24) − (25) | | | | | | | | |
| 27 | F&W LOSS | (10) | | | | | | | | |
| 28 | OUTPUT | (26) − (27) | | | | | | | | |
| 29 | OUTPUT H.P. | (28) ÷ 746 | | | | | | | | |
| 30 | R.P.M. ÷ SYN. | (26) ÷ (24) | | | | | | | | |
| 31 | R.P.M. | (30) × (3) | | | | | | | | |
| 32 | SEC. INPUT | (24) | | | | | | | | |
| 33 | IRON LOSS | (9) | | | | | | | | |
| 34 | PRIM. CU. LOSS | (22)² × (2) × (4) | | | | | | | | |
| 35 | INPUT | (32) + (33) + (34) | | | | | | | | |
| 36 | EFF. | (28) ÷ (35) | | | | | | | | |
| 37 | APP. WATTS | (1) × (2) × (22) | | | | | | | | |
| 38 | P.F. | (35) ÷ (37) | | | | | | | | |
| 39 | TORQUE | (24) × 7.04 ÷ (3) | | | | | | | | |

FIG. 15—WORKSHEET FOR CALCULATING PERFORMANCE BY CIRCLE DIAGRAM

1. Torque $= H\,P \dfrac{5252}{\text{Rev. per min.}}$ (Using test or estimated value of rev. per min.)
2. Secondary input = Torques $\dfrac{\text{Synchronous rev. per min.}}{7.04}$
3. Primary amperes = Secondary input × (*No convenient expression available*)
4. Secondary amperes = Secondary input − (*No convenient expression available*)
5. Secondary copper loss = (Secondary amperes)$^2$ × $r_2$ × phases
6. Secondary output = Secondary input—Secondary copper loss
7. Output = Secondary output—F and W loss
8. Rev. per min. $= \dfrac{\text{Secondary output}}{\text{Secondary input}} \times$ synchronous rev. per min.
9. Primary copper loss = (Primary amperes)$^2$ × $r_1$ × phases
10. Input = Secondary input + primary copper loss + iron loss
11. Efficiency $= \dfrac{\text{Output}}{\text{Input}}$
12. Power factor $= \dfrac{\text{Input}}{\text{Primary amperes} \times E \times \text{phases}}$

Starting with the horsepower for which a calculation is desired, the first step gives the torque while the second gives the input to the rotor. The next quantities wanted are the primary and secondary amperes; but the equations which might be written for these steps would be so elaborate and complicated as to involve many times more work than all the other steps in the calculation combined.

This directs attention to the fact that in any *rigorous* method of calculating polyphase induction motor performance, after the constants are known, the determination of the current values which correspond to any specified input makes nearly all of the work. In the Circle Diagram processes, these relations are determined graphically, while in the Steinmetz System the results are obtained by lengthy analytical equations.

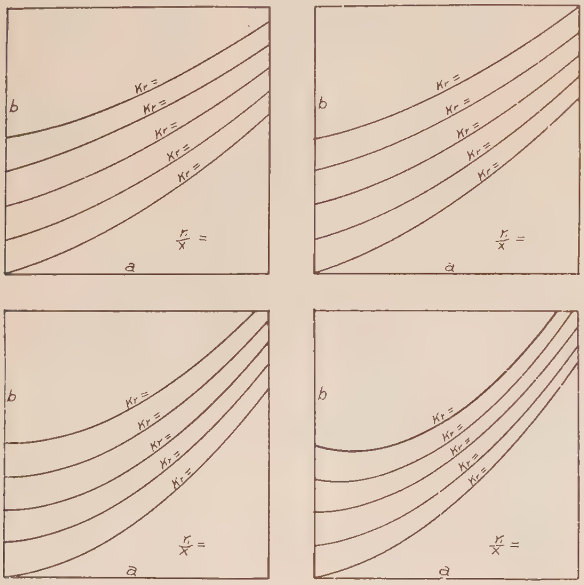



Fig. 16—Examples of $a\,b$ Curves

The most satisfactory scale is 0.02 per in. for or dinates and abscissas See Fig. 17A

In the system which this paper describes these tedious and lengthy processes are eliminated. The primary and secondary amperes are obtained with a negligible amount of labor by reference to two sets of curves, reduced examples of which are shown in Figs. 16 and 17. One set, known as the $a\,b$ curves, is used for primary amperes, while the other set known as the $a\,c$ curves, is used for secondary amperes. The values which the curves represent are geometrical relations from the circle diagram shown in Fig. 15, and are mathematical quantities of the same general character as sines or cosines. On both sets of curves the abscissa is marked $a$, while the ordinates are marked $b$ on the curves for primary amperes and $c$ on the curves for secondary amperes. In terms of the lines on the diagram, in Fig. 15,

$$a = \frac{T\,R}{O'\,H} \times \left(\frac{O\;E}{Z\,E}\right)^2$$ and *represents* secondary input

$$b = \frac{O\,T}{O'\,H} \times \frac{O\,E}{Z\,E}$$ and *represents* primary amperes

$$c = \frac{M\,T}{O'\,H \times K_p} \times \frac{O\,E}{Z\,E}$$ and *represents* secondary amperes

while in terms of the motor values,

$$a = \frac{\text{Secondary input}}{(E^2/X) \times \text{phases}}$$

$$b \times \frac{E}{X} = \text{primary amperes}$$

$$c \times \frac{E}{X} = \text{secondary amperes}$$

In a practical calculation, we complete the first and second items of the procedure outlined above and then obtain

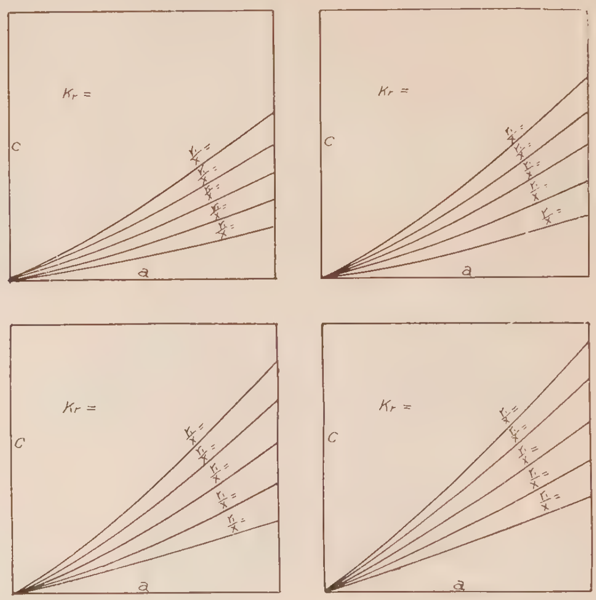



Fig. 17—Examples of $a\,c$ Curves

See Fig. 17A

$$a = \frac{\text{Secondary input}}{(E^2/X)\ \text{phases}}$$

Next using $a$ as abscissa we read $b$ and $c$ from the appropriate curves and as stated above

$$b \times \frac{E}{X} = \text{primary amperes}$$

$$c \times \frac{E}{X} = \text{secondary amperes}$$

## IX. Description of the Curve Sheets

In preparing the $a\ b$ and $a\ c$ curves, we take advantage of the fact that the geometrical construction of the circle diagram is determined by three constants.

If the voltage and current scales are so chosen as to make the lines $O\ E$ and $O'\ H$ (Fig. 14) of equal length, the only relations involved in the construction are

$$\frac{M\ H}{O'\ H} = \frac{X_o - X}{X_o} = K_p\, K_s = K_r$$

$$\frac{O\ Z}{O\ T} = \frac{r_1}{X}$$

$$\frac{O'\ O}{O'\ H} = \frac{\text{Core loss}}{(E^2/X)\ \text{phases}}$$

The general scheme of the $a\ b$ curves is illustrated by

| DATA | | |
|---|---|---|
| PREDETERMINED BY CALCULATION OR TEST | | |
| 1 | E, 2φ = LINE V.<br>E, 3φ = LINE V. ÷ 1.73 | 1000 |
| 2 | PHASES | 3 |
| 3 | SYN. SPEED | 1000 |
| 4 | $r_1$ (HOT) | 3 |
| 5 | $r_2$ (HOT)* | 4 |
| 6 | $r_2'$ ** | |
| 7 | X | 10 |
| 8 | $X_o$ | 100 |
| 9 | $F_E$ LOSS | 400 |
| 10 | F & W LOSS | 700 |
| FULL LOAD READINGS FROM TEST | | |
| 11 | R.P.M. | |
| 12 | F.L. AMPS. | |
| 13 | F.L. WATTS | |

| PRELIMINARY CALCULATIONS | | | |
|---|---|---|---|
| 14 | $r_1/X$ | 4 ÷ 7 | .3 |
| 15 | $r_2/X$ | 6 ÷ 7 | .4 |
| 16 | $K_r$ | (8 − 7) ÷ 8 | .9 |
| 17 | $E/X$ | 1 ÷ 7 | 100 |
| 18 | $E^2/X$ | 17 × 1 | 100 000 |
| 19 | $F_E X / E^2 \times$ PHASES | (9 × 7) ÷ ($1^2$ × 2) | .004 |
| 20 | CORRECTION | (19 − .005) × .6 | −.0006 |
| 21 | F.L.T. | (5252 × H.P.) ÷ 11 | 282 |

* THE SECONDARY RISISTANCE CANNOT BE DIRECTLY DETERMINED BY TEST. IT CAN BE DETERMINED ACCURATELY ONLY FROM THE SLIP. THE CORRECT VALUE OF $r_2$ IS THAT FROM WHICH THE CORRECT SPEED AS SHOWN BY ITEM 11 CAN BE CALCULATED.

TAKE A TRIAL VALUE OF $r_2$ AND CARRY THE CALCULATIONS DOWN ONLY TO ITEM 43 THEN

$$r_2\,(\text{CORRECT}) = r_2\begin{pmatrix}\text{TRIAL}\\ \text{VALUE}\end{pmatrix} \times \frac{\text{OBSERVED SLIP}}{\text{CALCULATED SLIP}}$$

ERASE ITEMS 5, 37, 42 AND 43; RE CALCULATE USING THE CORRECT VALUE OF $r_2$.

WHEN THE CONSTANTS HAVE BEEN CALCULATED USE THE CALCULATED VALUE OF $r_2$ IN DETERMINING THE SLIP. THE SECONDARY RESISTANCE USED FOR STARTING TORQUE, $r_2'$, HAS A SOMEWHAT HIGHER VALUE WHICH CANNOT BE CALCULATED. EXCEPT APPROXIMATELY BY EMPIRICAL METHODS.

** FROM LOCK READINGS.

† ITEMS 29 AND 30 MUST BE ADDED ALGEBRICALLY.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 27 | TORQUE | (H.P. × 5252) ÷ R.P.M | | | 282 | | | |
| 28 | SEC. INPUT PER φ | ([(27 × 3) ÷ 704] + 10) ÷ 2 | | | 13600 | | | |
| 29 | (a) UNCORRECTED | 28 ÷ 18 | | | .1360 | | | |
| 30 | CORRECTION | 20 | | | −.0006 | | | |
| 31 | (a) CORRECTED | 29 + 30 † | | | .1354 | | | |
| 32 | (b) | FROM CURVE - 31 AS ABSCISSA | | | .1879 | | | |
| 33 | PRIM. AMPS. | 32 × 17 | | | 18.79 | | | |
| 34 | (c) | FROM CURVE - 29 AS ABSCISSA | | | .1522 | | | |
| 35 | SEC. AMPS. | 34 × 17 | | | 15.22 | | | |
| 36 | SEC. INPUT | 28 × 2 | | | 40800 | | | |
| 37 | SEC. CU. LOSS | $35^2$ × 5 × 2 | | | 2780 | | | |
| 38 | SEC. OUTPUT | 36 − 37 | | | 38020 | | | |
| 39 | F & W LOSS | 10 | | | 700 | | | |
| 40 | OUTPUT WATTS | 38 − 39 | | | 37320 | | | |
| 41 | OUTPUT H.P. | 40 ÷ 746 | | | 50 | | | |
| 42 | R.P.M. ÷ SYN. | 38 ÷ 36 | | | .932 | | | |
| 43 | R.P.M. | 42 × 3 | | | 932 | | | |
| 44 | SEC. INPUT | 36 | | | 40800 | | | |
| 45 | $F_E$ LOSS | 9 | | | 400 | | | |
| 46 | PRIM. CU. LOSS | $33^2$ × 4 × 2 | | | 3175 | | | |
| 47 | INPUT WATTS | 44 + 45 + 46 | | | 44375 | | | |
| 48 | EFF. | 40 ÷ 47 | | | .843 | | | |
| 49 | APP. WATTS | 1 × 33 × 2 | | | 56450 | | | |
| 50 | P.F. | 47 ÷ 49 | | | .785 | | | |

Fig. 20—Worksheet for Calculating Performance by Use of $a\ b$ and $a\ c$ Curve Sheets Shown in Figs. 16 and 17

Fig. 16. All of the curves give the values of $b$ corresponding to the variations in the value of $a$ over as wide a range as practical work requires.

The various curves on one sheet relate to different values of $K_r$ but to the same values of the other constants, while each sheet relates to a different value of $r_1/X$.

To make the system logically complete it would be necessary to go a step further and make a separate set of curve sheets for each of a series of values of the third constant $\dfrac{F_e\,X}{E^2 \times \text{phases}}$. Such elaboration, however, is not necessary. The core loss affects the primary amperes to only a slight extent and as high a degree of accuracy as it is possible to utilize in slide rule work may be obtained by using for all the curves a mean value of $\dfrac{F_e\,X}{E^2 \times \text{phases}}$ and making an approximate compensating correction when the actual value differs appreciably from that on which the curves are based.

Therefore all the $a\ b$ curves are based on the assumption that $\dfrac{F_e\,X}{E^2 \times \text{phases}} = 0.005$ and the correction consists in adding algebraically to the value of $a$ which is used as abscissa for the $a\ b$ curve the quantity

$$\left(\frac{F_e\,X}{E^2 \times \text{phases}} - 0.005\right) 0.6$$

When this correction has been applied, the discrepancy in the primary ampere figures will not often exceed one-tenth of one per cent.

Since $\dfrac{F_e\,X}{E^2 \times \text{phases}}$ has no effect on the secondary amperes, it does not have to be considered in connection with the $a\ c$ curves, which are plotted as illustrated by Fig. 17.

## XII. Practical Procedure by the Curve Method

Full directions for making performance calculations from known constants will be found on the work sheet, Fig. 20.

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## CANDLES vs. INCANDESCENT LAMPS

Lighting one room with a 100-watt incandescent lamp for 300 hours, which is about the average burning time of a lamp a year, costs \$2.40 or less. Lighting another room of the same size, the same length of time and with the same brightness, using the original lamps made by Thomas A. Edison 50 years ago, would now cost more than \$20.00. At then existing rates for electric service the cost would have been much greater.

Going still further back in lighting methods and using candles, replacing them constantly as they burn down, and keeping a room of the same size lighted to the same brightness for the same length of time, would cost more than \$400.00.

Only the rich can now afford to burn candles!

In 1790, at a reception given in honor of George Washington, it took two thousand candles to illuminate the hall, costing about \$10.00 an hour. Today, electricity, giving the same degree of illumination, would cost only about twenty cents an hour.—*Transactions, I. E. S.*

Abridgment of

# Theory of a New Valve Type Lightning Arrester

BY J. SLEPIAN[1], Fellow, A. I. E. E.
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and
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*Synopsis.—Theory and experimental data are given on the properties of discharges confined to small holes, such as the pores of a naturally porous material. The characteristics of these discharges are such that they are well suited for utilization in a valve type lightning arrester.*

* * * * *

## I. The Valve Type Arrester

A VALVE type lightning arrester is an apparatus which passes current freely for impressed voltage in excess of a certain value, and which ceases to carry current almost completely for impressed voltage less than a certain other value. If the impressed voltage is increased continuously from a low value, that voltage at which current begins to be passed freely is called the breakdown voltage. After the breakdown voltage is exceeded, if the voltage is decreased continuously, the arrester will generally continue to pass current relatively freely until a lower value of voltage is reached at which discharge of current substantially ceases. This voltage at which current flow nearly stops we shall call the cut-off voltage of the valve arrester.

The largest voltage which appears across an arrester during a normal discharge we shall call the maximum voltage of the arrester. The ratio of this maximum voltage to the cut-off voltage we shall call the voltage ratio of the arrester.

It is evident that the voltage ratio of a valve type arrester determines its protective value on an electrical system, for the cut-off voltage must be proportional to the normal working voltage of the system, and then the maximum voltage of the arrester will determine the stress which the system insulation will receive during lightning. The characteristics of electrical insulation under impulse voltages are such that a properly applied arrester with voltage ratio of two or three will give almost perfect protection. A valve arrester with a voltage ratio of ten or more will have little protective value.

A valve type arrester must change from a good conductor to a relatively good insulator over a moderate change of voltage. The field of discharges in gases would seem to offer the best possibilities for the realization of these characteristics. Examination of the field, however, reveals that although valve effects are generally present, their voltage ratio is not sufficiently low to be useful except in a few special cases or arrangements.

It is clear that the volt-ampere characteristic of the discharge which follows breakdown must be studied to determine the lowest voltage which will maintain the discharge under given conditions. This will be the cut-off voltage of the arrester constructed utilizing this type of discharge. It is also clear that types of discharge must be sought which require a high voltage for their maintenance. In this way, the cut-off voltage may be brought up to the order of magnitude of the breakdown voltage, and thus a low voltage ratio may be obtained.

In the autovalve arrester,[3] for example, by the use of electrodes of relatively high resistivity, the discharge is constrained to remain in the form of a glow instead of being permitted to take the form of an arc which is the more usual form at atmospheric pressures. The glow is distinguished from the arc, in that it requires a minimum of several hundred volts for its maintenance as compared with about 20 volts for a very short arc. By using very short spacings between the high resistivity electrodes, the breakdown voltage also is made to be only several hundred volts, and thus a very low voltage ratio is obtained.

## II. Electrical Discharges in Holes and Fine Capillaries

Another method of obtaining a discharge which requires for its maintenance a voltage comparable with that required to initiate the discharge has been discovered. It has been found that the voltage required to maintain a discharge can be raised to high values by confining the discharge to narrow passages with insulating walls.

In Fig. 3, the heavy line indicates the volt-ampere characteristic of a discharge in the open at atmospheric pressure. The dotted curve *A* indicates that of a discharge confined to a circular hole. For small currents, where the natural section of the discharge is less than that of the hole, the walls of the hole have little influence upon the discharge, and the voltage is the same as that for a discharge in the open. When the discharge fills the hole, however, the voltage is increased and the curve *A* departs from the solid curve. With further increase of current, the confining action of the hole

1. With Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

*Presented at the Great Lakes District Meeting of the A. I. E. E., Chicago, Ill., Dec. 2-4, 1929. Complete copy upon request.*

3. J. Slepian, Trans. of A. I. E. E., XLV, 1926, p. 169.

becomes so great that the voltage increases with increasing current. Curve *B* in Fig. 3 indicates the effect of a smaller hole. The departure from the solid curve for the discharge in the open occurs at smaller current and higher voltage.

From these curves, we are led to believe that for discharges confined to holes at atmospheric pressure, there is a minimum voltage which occurs at a relatively small current, and that with smaller holes this minimum

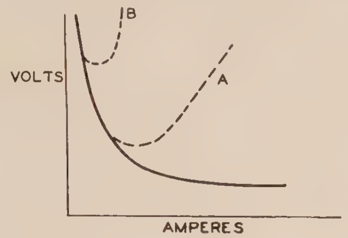


Fig. 3—Volt-Ampere Characteristic of Discharge in the Open and in Holes of Different Sizes

voltage is greater, and occurs at smaller currents. This is confirmed by the work of R. C. Mason who obtained the volt-ampere characteristics of discharges in holes in soapstone, the discharge being started by a fine fuse wire, and the current and voltage values measured from an oscillogram. The existence of a

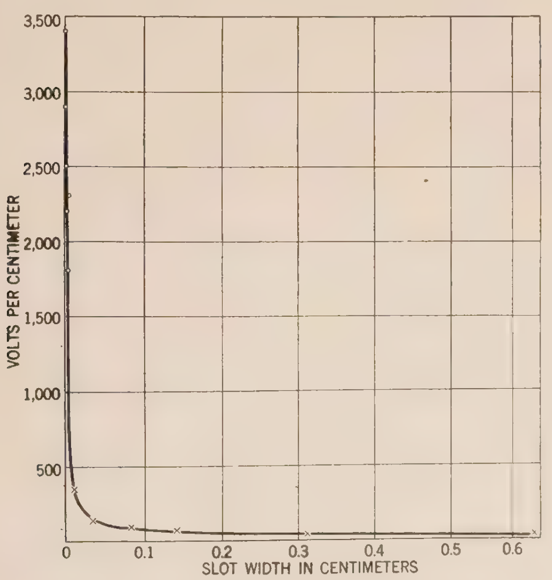


Fig 5—Minimum Voltage Gradient for Discharges in Slots

minimum voltage gradient of considerable magnitude and occurring at a small value of current was brought out in his work. Mason has also obtained data showing that the minimum voltage gradient is increased as the size of the hole is decreased. In Fig. 5 the crosses indicate the minimum voltages observed by Mason for discharges in slots with soapstone walls of varying width. These discharges were started by fine fuse wires in a 60-cycle circuit, and oscillograms taken of current and voltage. The circles in Fig. 5 indicate the results obtained by the authors for very narrow slots between glass plates. These discharges were started disruptively by application of very high voltage, and a cathode ray oscillogram was taken of the volt-ampere characteristics.

## III. Discharges in Naturally Porous Materials

The data of Fig. 5 show that to obtain minimum discharge voltage gradients of the order of several thousand volts per cm. at atmospheric pressure and thus of an order of magnitude beginning to be comparable with breakdown voltage gradients, the passages to which the discharges are confined must have sections with linear dimensions less than 0.00 1 cm. With such small dimensions, the current carried by a passage with the voltage gradient maintained at breakdown value will be very small. For lightning arrester purposes, therefore, it will be necessary to use a very large number of these very fine passages in parallel. It would not be practical to construct or assemble directly, such a multitude of fine passages or channels. Materials can be made,

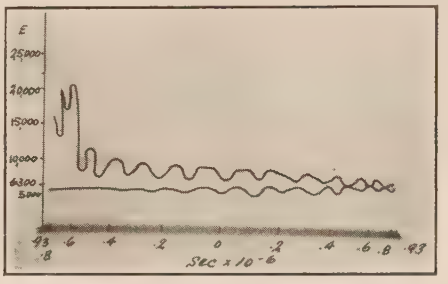

Fig. 6—Discharge through Piece of Red Brick

however, which are naturally permeated by fine pores whose sections are of the required dimensions.

In Fig. 6, for example, is given a cathode ray oscillogram showing the course of the voltage with the time, for a discharge from a condenser through a piece of red building brick, 7 mm. thick. Breakdown occurred at about 22,500 volts. The voltage then dropped sharply to about 10,000 volts, and then dropped slowly to about 5000 volts, where, as the current decreased, it remained nearly stationary. This indicates that most of the pores had minimum discharge voltages or cut-off voltages of about 5000 volts. In terms of gradients, breakdown occurred at 32,000 volts/cm. and cut-off for most of the pores at 7100 volts/cm. The brick appeared to be uninjured by the discharge and the experiment could be repeated, reproducing the oscillogram and thus indicating that the discharge had passed only through the pores of the brick without affecting the solid material.

Before showing volt-ampere oscillograms of discharges through porous materials, it will be well to consider what characteristic may be expected from consideration of the volt-ampere characteristic of a single fine hole as shown in Fig. 3. In Fig. 7A, the full curve shows the static volt-ampere characteristic of a discharge in a very fine long hole. Breakdown occurs at

*A*, and the minimum or cut-off voltage is shown at *C*. If the voltage impressed along the hole is raised to the breakdown point *A*, and then held at this value, the current will at once build up to that corresponding to *B*, which is the other intersection of the horizontal through *A* with the static characteristic. If the voltage is now lowered, the current will decrease following the curve *B C* until the cut-off point *C* is reached. If now the voltage is lowered only slightly, and held constant, the discharge can no longer be maintained, and the current decreases rapidly to zero along the line *C F*. Raising

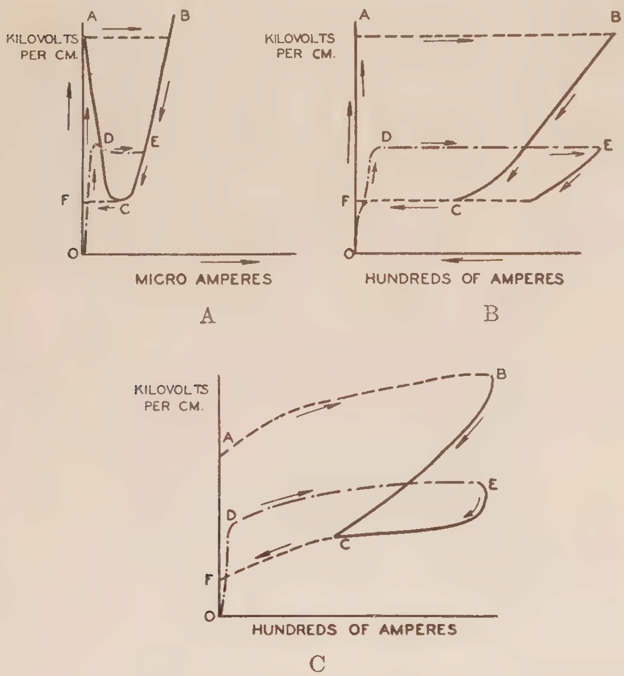


Fig. 7—Characteristics of Discharges in Five Holes

the voltage to the breakdown value and then lowering it, thus causes the loop *O A B C F* to be traced.

If now a hundred million fine holes, each having identically the characteristic of Fig. 7A, are used in parallel, it is clear that when the voltage is raised to the breakdown value each individual hole will break down carrying its own few microamperes, and that when the voltage is lowered to the common cut-off value each hole will cease carrying its minute current. A volt-ampere loop *O A B C F* is obtained for the multitude of holes entirely similar that for a single hole except that the current scale is in hundreds of amperes instead of microamperes. (Fig. 7B).

In an actual porous material, the hundreds of millions of fine holes which are its pores will not all have the same breakdown voltage. The volt-ampere loop will therefore be modified as shown in Fig. 7C. Current will first flow when the voltage reaches *A*, the breakdown voltage of the pores having the lowest breakdown value. As the voltage is further increased the current increases in two manners. First, the current carried by those pores which are already broken down increases. And also, with increase of voltage, the breakdown value of more pores is exceeded and these additional pores begin to carry current. Thus, the upper portion of the volt-ampere loop slopes upward as in Fig. 7C.

The pores of an actual porous material will also not all have the same minimum or cut-off voltage. This will cause the lower branch of the volt-ampere loop to be modified as in Fig. 7C. As the voltage is lowered from the point *B*, the current decreases because the current in each pore decreases. When the point *C* is reached, some of the pores stop carrying current altogether because their cut-off voltage has been reached. Along the portion *C F* more and more of the pores cease carrying current, and at *F*, the cut-off of the last pore is reached.

Regarded as a lightning arrester, the breakdown voltage of the porous material is the breakdown voltage of the pore having the lowest breakdown, and the cut-off voltage of the porous material is the cut-off voltage of the pore having the lowest cut-off.

It may be concluded therefore that finely porous materials will have high cut-off voltages.

This is confirmed in the curve of Fig. 8, which shows the cut-off voltage for four porous materials, determined by cathode ray oscillograms. An average pore diameter for these materials was estimated by B. S.

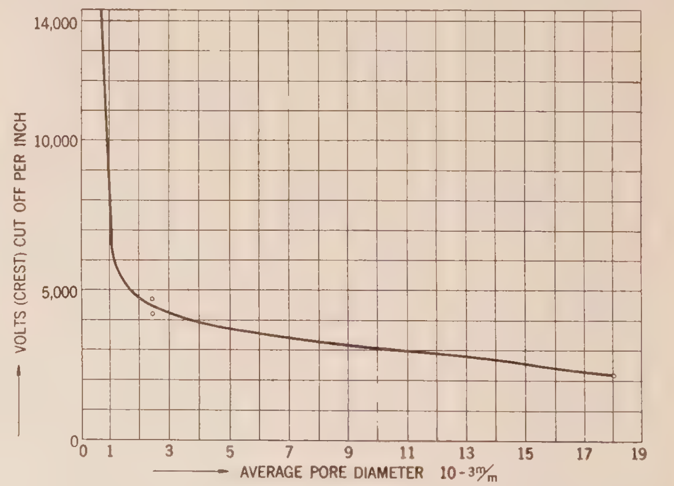


Fig. 8—Relation between Cut-off Voltage and Average Pore Diameter

Covell by a determination of the pore volume, and from the rate at which a fluid under pressure flowed through the materials.

## IV. Discharges in Slightly Conducting Porous Materials

By confining the discharge following breakdown to very fine channels it is possible as we have seen to raise greatly the minimum voltage for maintaining the discharge, and thus greatly improve the valve effect. To obtain a voltage ratio sufficiently low to make a good valve type lightning arrester, however, calls for a material with pores of an exceedingly great degree of fineness. The authors have found that by incorporat-

ing small amounts of conducting material such as lampblack or powdered metal in the porous material the breakdown voltage is considerably reduced while the cut-off voltage is unaffected. In this way, it is possible to greatly improve the valve effect and to reduce the stringency of the requirement as to the fineness of the pores.

Fig. 10, for example, shows cathode ray oscillograms of volt-ampere loops of porous disks 5.0 cm. in diameter and 3.2 mm. thick which were practically free from conducting material so that their resistance when measured at 1000 volts was about 2000 megohms.

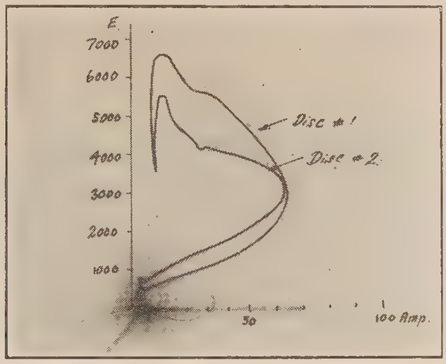


Fig. 10—Discharge through Insulating Porous Disks

Fig. 11 shows the characteristics of a similar disk but containing a small amount of carbon so that its resistance when measured at 1000 volts was 30,000 ohms. Comparing the two oscillograms, we see that the addition of the carbon had only a very slight effect upon the lower or cut-off branch of the loop, whereas it greatly lowered the upper or breakdown branch, thus greatly improving the valve effect.

The way in which the finely divided conducting material causes the breakdown voltage to be lowered is readily pictured. The conducting particles are distributed through the porous material, and are too few in number to form many conducting paths through the material. The few continuous chains of conducting particles through the material account for the conductivity at low voltage (30,000 ohms in the disk of Fig. 11).

Besides these continuous chains, there will be some chains of conducting particles which are not completely continuous but have tiny breaks in them. When the voltage impressed on the piece is raised to a few hundred volts those chains which have single tiny breaks will begin to carry current, a discharge occurring across the tiny break in each chain. The current in this discharge is kept small by the high resistance of the fine chain leading up to the break. As the voltage is further raised, chains of conducting particles with two or more breaks begin to carry current. Thus, the porous material becomes permeated with these tiny discharges across the minute breaks in the conducting chains.

The presence of these tiny pilot discharges will cause the breakdown in the various pores to be lowered very greatly. This is shown in Fig. 7A by the loop *O D E F*. As the voltage is raised from zero there is now a leakage current due to the conducting chains. When the point *D* is reached enough pilot discharges have formed to cause the fine hole to break down as a whole. The current then increases to the value at point *E* on the rising part of the volt-ampere curve for a discharge in the hole. If the voltage is now lowered, at *C* the cut-off voltage for the hole, the current will drop to the leakage value at *F*. The effect of the addition of conducting material is shown also in the loops *O D E C F* in Figs. 7B and 7C.

It will be noticed that the current taken by the hole at the breakdown voltage is lessened when the conducting material is added. Hence, with a multiplicity of holes in parallel for the discharge of a given current more holes will participate, as is clear from Figs. 7B and 7C. Thus, the duty on each hole resulting from the mechanical stress due to the pressure developed by the discharge is lessened since both the voltage and the current are lowered. This is a very important advantage obtained by the addition of the conducting material. The tendency to shatter or puncture observed in insulating porous material when subjected to very heavy discharges was almost completely eliminated by the addition of the proper amount of conducting material.

The amount of conducting material added to the porous material must of course be properly chosen if desirable lightning arrester characteristics are to be obtained. If too little is used, the breakdown voltage will be high in comparison with the cut-off voltage, and the material will also tend to shatter or puncture. If too much is used the large leakage current will cause the cut-off to be vague and impose too great a duty on the series spark-gap.

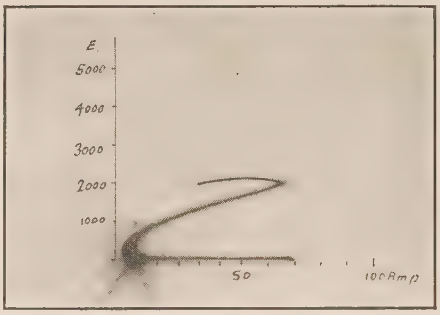


Fig. 11—Discharge through Slightly Conducting Porous Disks

## Conclusions

The theory and experimental work described above show that there are good possibilities for the development of a valve type arrester utilizing discharges confined to fine pores of a naturally porous material. In a later paper, the authors hope to show how these possibilities have been realized.

Abridgment of

# Three-Phase Short-Circuit Synchronous Machines—V

BY R. E. DOHERTY[1] and C. A. NICKLE[2]

Member, A. I. E. E. Associate, A. I. E. E.

***Synopsis.**—This paper is the fifth of a series which the authors' have presented on the subject of synchronous machines. Part I was an extension of the fundamental theory; Part II, a treatment of torque-angle characteristics under steady-state conditions; Part III, a study of torque-angle characteristics under transient conditions; and Part IV, an analysis of single-phase short-circuits. In the present paper equations for the currents in the armature phases and field under three-phase short-circuit are developed.*

*The analysis is divided into three parts: The first covers the case of short-circuit at no-load when the resistance is negligible in determining the magnitude of the current although it must naturally be considered in finding the decrement factors; the second considers the same case where the resistance does effect the magnitude of the current; the third covers the case of short-circuit under load when resistance is negligible as in the first case.*

*The effect of the nature of the load,—i. e., whether the power factor is lagging or leading,—is studied and some interesting results are brought out. It is shown that short circuits under load may give less current than at no-load; and it is further developed that under certain practical operating conditions, it is even possible to obtain substantially no fundamental current.*

*The paper is illustrated with comparisons of calculated curves and oscillograms showing the actual currents obtained in test. Some of the interesting points concerning the nature of the short-circuit currents and the manner in which they are influenced by the design of the machine are mentioned in the discussion of results.*

## INTRODUCTION

A HISTORICAL treatment of special cases of short circuits was given in Synchronous Machines IV. It was mentioned there that the solution for three-phase short circuit of the cylindrical rotor machine, under the assumption of negligible saturation, had been published by other authors; Dreyfus (14), Lyon (13), Shimidzu and Ito (8), Biermanns (3), Bekku (12), and Ku (16) have all given thorough mathematical treatment of this type of machine. A general expression for current on three-phase short circuit, covering the case of salient-poles, was included in a paper by Park, (*Two-Reaction Theory of Synchronous Machines*, bibl. 15b) presented at the 1929 Winter Convention.

The advance over the authors' previous studies of three-phase short circuits, which is made in the present analysis, is in its treatment of the salient-pole case. That is; the present analysis considers both cylindrical-rotor and salient-pole machines, including the effect of load.

## ASSUMPTIONS

1. *Negligible Saturation.* This assumption is, of course, a deviation from the practical machine. However, as explained in previous papers of this series, the results may nevertheless be used with judgment as an approximation.

2. *The Armature Phase M. M. F. is Sinusoidally Distributed.* This is practically true of most modern machines so that no appreciable error is involved on this score in applying the results to practical cases.[3]

3. *Only One Rotor Circuit.* The machine is assumed to have only one rotor circuit, *i. e.*, the main field winding in the direct axis.

## Part I

Part I covers the case of a dead three-phase short circuit at the terminals of the machine. Only the internal resistance of the machine windings is involved and in most cases this resistance is entirely negligible in determining the magnitude of the short-circuit currents. By equating expressions for the total flux linkages in each phase at any instant after short circuit to the linkages which existed at the instant of short circuit and solving the resulting equations, expressions are obtained for the short-circuit armature and field currents, which are as follows,

$$i = \frac{e_o}{x_d} \cos (t - \alpha) + e_o \frac{x_d - x_d'}{x_d\, x_d'} \epsilon^{-\sigma_f t} \cos (t - \alpha)$$

$$- e_o \frac{x_d' + x_q}{2\, x_d'\, x_q} \epsilon^{-\sigma_a t} \cos \alpha$$

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*Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 27-31, 1930. Complete copy upon request.*

3. This assumption is equivalent to the following:

a. That the mutual inductance of the armature and field circuits is a first harmonic only with respect to the electrical space angle.

b. That the armature self and mutual inductance with respect to the field winding and other armature windings, contain only the zero and second harmonics.

c. That the second harmonic of armature self-inductance is equal to the second harmonic of armature mutual inductance with respect to other phases. This follows from Equation (5), reference (15a).

$$+ e_o \frac{x_d' - x_q}{2\, x_d'\, x_q}\, \epsilon^{-\sigma_a t} \cos (2\, t - \alpha)$$

$$I = e_o \frac{x_d}{x_d'} - e_o \frac{x_d - x_d'}{x_d'} \cos t$$

where $i$ is the armature phase current in general, $I$ is the field current, $e_o$ is the terminal voltage existing before short circuit, $x_d$ and $x_q$ are the synchronous reactances in the direct and quadrature axes, and $x_d'$ is the transient reactance of the direct axis; $\alpha$ is the angle between the axis of the field pole and the axis of the armature phase winding at the instant of short circuit.

A

B

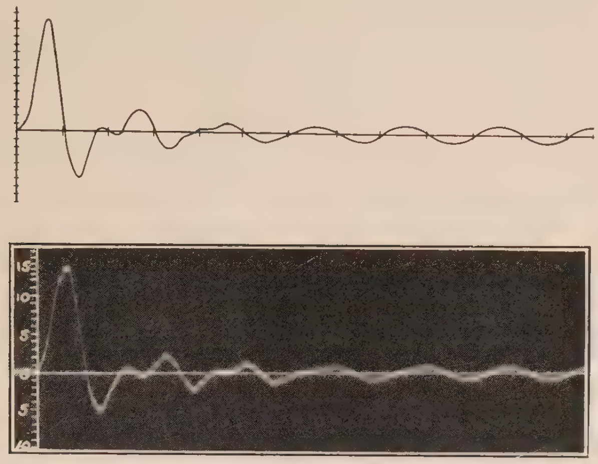


Fig. 3—Transient Armature Current in Phase $A$ on Balanced Three-Phase Short Circuit. Approximate Zero Flux Linkages with Phase $A$ ($\alpha$ = 80 Deg.) Round Rotor Machine

Curve $A$. Calculated curve
Curve $B$. Test curve

Equation:

$$i_a = \cos (t + 80) + 16.95\, \epsilon^{-0.36\, t} \cos (t + 80) - 9.46 \cos (t + 80) - 8.47 \cos (2\, t + 80)$$

A

B

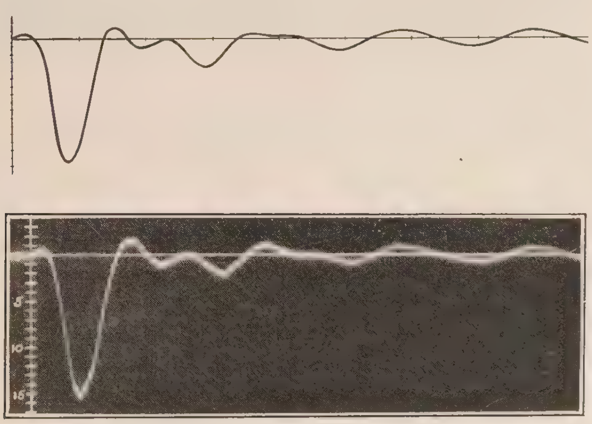


Fig. 4—Transient Armature Current in Phase $A$ on Balanced Three-Phase Short Circuit. Maximum Initial Flux Linkages with Phase $A$ Round Rotor Machine

Curve $A$. Calculated curve
Curve $B$. Test curve

Equation:

$$i_a = \cos t + 16.95\, \epsilon^{-0.36t} \cos t - 9.46\, \epsilon^{-0.238t} - 8.47\, \epsilon^{-0.238t} \cos 2$$

## Part II

The results of Part I may be extended to cover the case of a short circuit occurring through external reactance simply by modifying the reactance coefficients of the machine. When the resistance is negligible, the results will be accurate. It remains, however, to consider the case of short circuit occurring through external resistance which is not negligible. In the equations derived in this section of the paper, values of total resistance, including the internal resistance of the machine windings, may be used; hence, Part II considers three-phase short circuit with armature resistance.

A

B

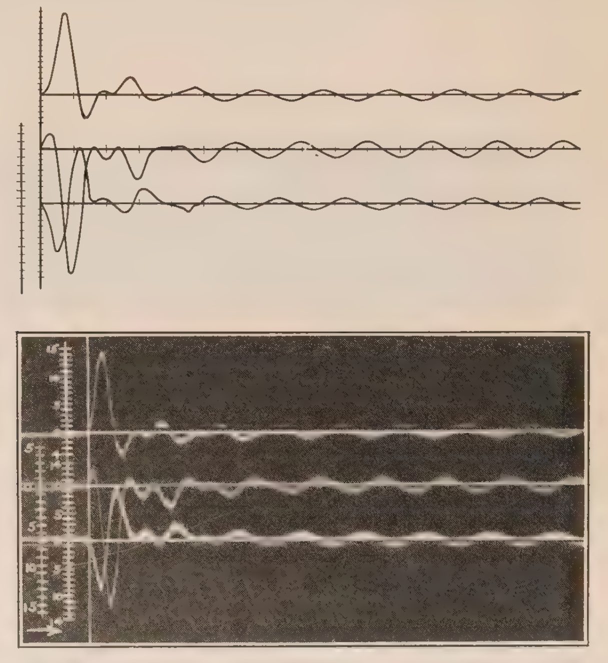


Fig. 5—Transient Armature Currents for Balanced Three-Phase Short Circuit. Maximum Initial Armature Linkages with Phase-$B$ Round Rotor Machine

Curves $A$. Calclated curves
Curves $B$ Test curves

Equations:

$$i_a = \cos t + 16.95\, \epsilon^{-0.36t} \cos (t - 120) + 4.73\, \epsilon^{-0.238t} - 8.45\, \epsilon^{0.238t} \cos (2\, t - 120)$$

$$i_b = \cos t + 16.95\, \epsilon^{-0.36t} \cos t - 9.46\, \epsilon^{-0.238t} - 8.45\, \epsilon^{0.238t} \cos 2$$

$$i_c = \cos t + 16.95\, \epsilon^{-0.36t} \cos (t - 240) + 4.73\, \epsilon^{-0.238t} - 8.45\, \epsilon^{-0.238t} \cos (2\, t - 240)$$

Under this condition, expressions for the currents in the armature and field are obtained through an analysis of the vector diagram of a salient-pole machine. The resulting expressions are:

$$i = \left[ \frac{e_d' \sqrt{r^2 + x_q^2}}{r^2 + x_d'\, x_q'} - \frac{e_d' \sqrt{r^2 + x_q^2}}{r^2 + x_d\, x'} \right] \epsilon^{-\sigma_f t} \sin t$$

$$+ \frac{e_d' \sqrt{r^2 + x_q^2}}{r^2 + x_d\, x_q} \sin t$$

$$I = e_d' \left[ 1 + \frac{x_q\, (x_q - x_d')}{r^2 + x_d'\, x_q} \right]$$

where $r$ is the total resistance from the point of short circuit to the neutral of the machine and $e_d'$ is the nominal voltage in the direct axis before short circuit.

## Part III

Part III covers the case of a dead short circuit at the terminals of a machine which is running under load.

A

B

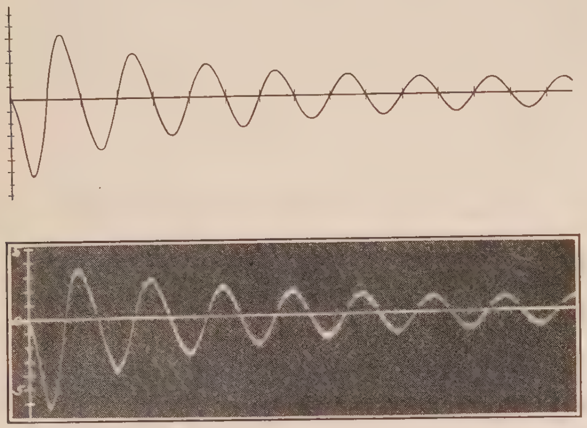


FIG. 6—TRANSIENT FIELD CURRENT ON BALANCED THREE-PHASE SHORT CIRCUIT. ROUND ROTOR MACHINE

Curve *A*. Calculated curve
Curve *B*. Test curve

Equation:

$i_f = 1 + 16.95\ \epsilon^{-0.36t} - 16.95\ \epsilon^{-0.238t} \cos t$

A

B

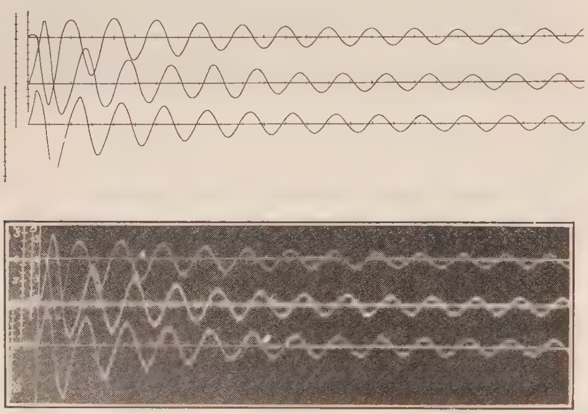


FIG. 9—TRANSIENT ARMATURE CURRENTS FOR BALANCED THREE-PHASE SHORT CIRCUIT. MAXIMUM INITIAL ARMATURE LINKAGES WITH PHASE-*A* SALIENT-POLE MACHINE

Curves *A*. Calculated curves
Curves *B*. Test curves

Equations:

$$i_a = \cos t + 5.37 \cos t\ \epsilon^{-0.0658t} - 4.35\ \epsilon^{-0.1773t} - 2.02 \cos 2t\ \epsilon^{-0.1773t}$$

$$i_b = \cos(t - 120) + 5.37 \cos(t - 120)\ \epsilon^{-0.0658t} + 2.17\ \epsilon^{-0.1773t}\ 2.02 \cos(2t - 120)\ \epsilon^{-0.1773t}$$

$$i_c = -\cos(t - 240) - 5.37 \cos(t - 240)\ \epsilon^{-0.0658t} + 2.17\ \epsilon^{-0.1773t} + 2.02 \cos(2t - 240)\ \epsilon^{-0.1773t}$$

This is similar to a no-load short circuit, the only difference being in the initial conditions.

In order to obtain expressions for current in this case the components of the current are analyzed independently. The expression for the component of fundamental frequency is obtained from the vector diagram of a salient-pole machine under load conditions. Expressions for the direct and second harmonic components are derived from data obtained in the derivation of the equations for Part I. These expressions, added together, result in the following formulas for total current on short circuit.

$$i_a = \frac{e_d'}{x_d} \cos(t - \alpha) + \left[ \frac{e_t' \cos\delta}{x_d'} - \frac{e_d'}{x_d} + i_d' \right]$$

$$\epsilon^{-\sigma_f t} \cos(t - \alpha) - e_t' \frac{x_d' + x_q}{2\, x_d'\, x_q}\ \epsilon^{-\sigma_a t} \cos(\delta + \alpha)$$

$$+ e_t' \frac{x_d' - x_q}{2\, x_d'\, x_q}\ \epsilon^{-\sigma_a t} \cos\delta \cos(2t - \alpha)$$

A

B

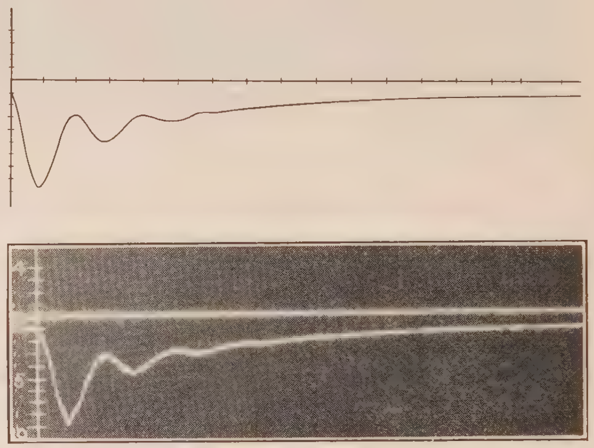


FIG. 10—TRANSIENT FIELD CURRENT ON BALANCED THREE-PHASE SHORT CIRCUIT. SALIENT-POLE MACHINE

Curve *A*. Calculated curve
Curve *B*. Test curve

Equation:

$i_f = 1.0 + 5.37\ \epsilon^{-0.0658t} - 5.37\ \epsilon^{-0.1773t} \cos t$

$$+ e_t' \frac{x_d' - x_q}{2\, x_d'\, x_q}\ \epsilon^{-\sigma_a t} \cos(\delta + 90) \cos(2t - \alpha - 90)$$

$$I = e_d' + e_t' \cos\delta\ \frac{x_d - x_d'}{x_d'}\ \epsilon^{-\sigma_f t} - e_t' \cos\delta$$

$$\frac{x_d - x_d'}{x_d'}\ \epsilon^{-\sigma_a t} \cos t$$

where $e_t'$ is the terminal voltage before short circuit and $\delta$ is the displacement angle between the direct axis nominal voltage and the terminal voltage. $i_d'$ is the component of the initial load current in the direct axis.

### DISCUSSION OF RESULTS

Although the results are based upon the premise

that only one rotor circuit exists, more general expressions covering the case of machines having amortisseur windings can be developed. For instance, in the case of short circuit at no-load, where resistance is negligible if the existence of an amortisseur winding is assumed and the subtransient reactances, $x_d''$ and $x_q''$, used in the derivation instead of $x_d'$ and $x_q$, general expressions will be obtained which are identical with those given in Part I, except that $x_d''$ and $x_q''$ replace $x_d'$ and $x_q$ respectively. It is immediately evident from these expressions that the second harmonic current depends upon the difference in the subtransient reactances of the direct and quadrature axes and may be practically eliminated by the presence of a good amortisseur winding.

The expressions obtained in terms of the subtransient reactances, may have some use in determining the maximum limit which the current can reach although it is likely that the result will be grossly too large since the current is made up of components, some of which are high-speed "transients," vanishing before the first peak of the current wave has been reached. When more than one rotor circuit is present in either axis of the machine these circuits are mutually coupled so that the determination of exact expressions for the components of current and their decrements is difficult. Equivalent circuits may be established and analyzed or the differential equations of the various circuits developed and solved. The procedure in the latter method has already been shown.

In the case of a short circuit occurring when resistance is appreciable, the armature m. m. f. will be displaced from the rotor axes of symmetry causing mutual coupling of the rotor circuits in the two axes. Work has been done toward obtaining complete expressions for current, assuming the presence of an amortisseur winding, for the three cases considered in the present treatment. This, however, is beyond the scope of the paper.

In the case of a short circuit occurring with the machine under load, it is interesting to note from the equations of Part III, the effect of the nature of the load on the current. Consider a cylindrical-rotor laminated machine with the following constant,

$$x_d = 1.00 \qquad x_d' = 0.30$$

$$x_q = 1.00 \qquad x_q' = 1.00$$

Then for an initial load of rated kv-a. at normal voltage, the fundamental short-circuit current as a function of power-factor is,

| | P. F. | $e_d'$ | $\delta$ | $i_d'$ | $i_q'$ | $i$ |
|---|---|---|---|---|---|---|
| ↑ | 0 | 2.0 | 0 | 1.0 | 0. | 4.33 |
| Lag | 0.50 | 1.94 | 15 | 0.966 | 0.259 | 4.18 |
| | 1.00 | 1.414 | 45 | 0.707 | 0.707 | 3.064 |
| Lead | 0.50 | 0.517 | 75 | 0.259 | 0.966 | 1.123 |
| ↓ | 0 | 0 | 90 | 0 | 1.0 | 0 |

Thus in the practical case of a round-rotor machine supplying the charging current of a line, it is possible to obtain substantially no fundamental current on short circuit.

It will also be noticed that for a unity power-factor load, the fundamental short-circuit current is less than for a short circuit at no-load. In the latter case the fundamental current would be $\dfrac{e_o}{x_d'} = 3.33$ times normal. Hence, when the machine is initially under load, the total short-circuit current may be less than if the machine were carrying no-load.

### Comparison of Calculated and Test Results

Calculations and tests were made on a 15-kv-a.; 1800-rev. per min., 60-cycle, 220-volt, salient-pole generator and a 20-hp., 1800-rev. per min., 60-cycle, 110-volt induction machine. Illustrations of the check between calculations and tests are shown for a few cases of short circuit under different conditions. Additional illustrations and detailed data on the two machines are given in the complete paper.

### Acknowledgments

The authors gratefully acknowledge the work of Mr. T. M. Linville in supervising the tests, making numerical calculations, assembling the material, and writing the paper; and of R. H. Park in critically reviewing the theory and results.

## SHADED LIGHTING

Too much cannot be said in favor of shaded lighting. Comparing shaded light with the bare lamp glare there is everything in favor of the shaded fixture. Soft light is always desirable. Its possibilities for decoration and its soothing effect on its surrounding contrast sharply against the undressed balls of flame which blind the eye and fray the nerves.

Popular style, however, has of late years largely favored the bare candle and exposed drop lights despite the logical reasons against them.

The style however is fast veering toward shaded lighting—concealed light sources—indirect lighting and semi-indirect.

Glare, enemy of the comfort and health of mankind might be controlled in public places by municipal ordinance; but in the home, where the most damage is done it can be prevented seemingly only by the element of style.

An investigation among the various lighting fixture manufacturing plants indicates a rapidly growing conception of the public desire for new glareless lighting. Glass manufacturers are showing many new styles in glass shades to meet this new style condition.—*Lighting Fixtures and Lighting.*

Abridgment of

# Tap Changing Under Load
## for Voltage and Phase-Angle Control

BY HOMER B. WEST[1]

Associate, A. I. E. E.

*Synopsis.*—*One of the most important and sometimes most involved, problems brought about by the many interconnections of electrical systems, is a means of accurate and flexible regulation of power flow. The adjustment of voltage and the control of wattless current by means of tap-changing-under-load equipment has become quite extensive. The regulation of power flow by means of phase-angle control has been put into practise on a limited scale. One means of accomplishing this which has been used in a few cases and which is being considered on a larger scale is the adaptation of tap-changing-under-load equipment with properly connected static transformers.*

*The purpose of this paper is to discuss briefly the connections employed and the equipment used in connection with static transformers for the purpose of voltage and phase-angle control.*

### INTRODUCTION

THE rapidly increasing number of interconnections between power systems is making possible the shifting of loads from one system to another in either direction in response to the diversity of system loads, and is resulting in improvements in the quality of service and in economies due to savings in plant capacity. The extent of interconnections can be appreciated when one realizes that the aggregate transformer capacity now installed with adjustable voltage ratio under load amounts to more than five million kv-a. A large percentage of this equipment is used for system interconnections.

### VOLTAGE CONTROL

When two systems are tied together at one point and have no other interconnections, a difference between the two system voltages at the point of interconnection will cause wattless kv-a. to flow from the system with higher voltage to the system with lower voltage. Transformers with equipment for changing the voltage ratio under load are used to compensate for the difference between system voltages and control the interchange of wattless kv-a.

Fig. 1 is an interesting example of tap-changing-under load equipment for this application. In addition to system interconnections, many other applications for tap-changing-under-load equipment for voltage control have been found. Examples of such applications exist where the equipment is used to compensate for line and transformer drop in transmission circuits, to maintain the voltage at secondary distribution buses, between predetermined limits, and in the supplying of power to synchronous converters and furnace transformers. An example of the latter application is the use of an 8120-kv-a., 25-cycle, single-phase, 12,000-volt furnace transformer with a low voltage range of 60 to 30 volts in 64 steps of less than one-half volt each, obtained by the "UB" equipment later described in this paper.

The needs of many users of voltage-ratio adjusting equipment are usually met with a range of 10 per cent adjustment above and below normal voltage. Now and then a greater range is needed but equipment for more than 10 per cent regulation, up and down, is becoming more rare. The manufacturer's practise with tap changing equipment seems to be resolving itself into the building of a standardized equipment, giving a total voltage range of 20 per cent with 10 per cent regulation above normal in four steps and 10 per cent below normal in four steps. If a greater ratio adjustment than 10 per cent is needed and it can be used in four steps up and down, the standardized equipment may be used by providing suitable taps in the transformer winding.

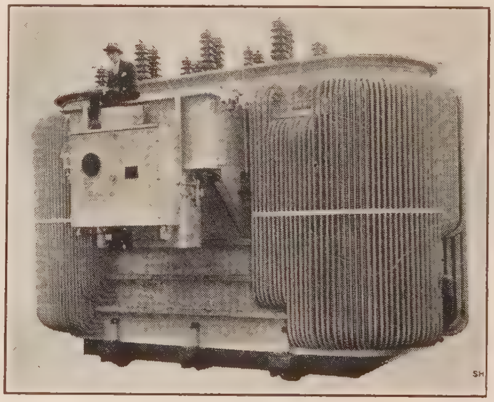


FIG. 1—SEPARATE REGULATING TRANSFORMER COMPLETE WITH TAP-CHANGING-UNDER-LOAD EQUIPMENT FOR 11 PER CENT VOLTAGE REGULATION ON A 50,000-KV-A., THREE-PHASE, 24,000-VOLT CIRCUIT

There are three fundamental methods of changing the voltage ratio of transformers under load: (1) by induction regulators or step induction regulators; (2) by the parallel-winding method; and (3) by the single-winding method.[2]

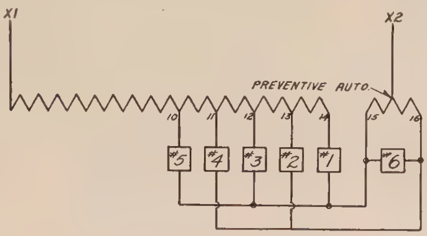
1. Transformer Engineering Department, Westinghouse Electric & Manufacturing Company, Sharon, Pa.

*Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 27-31, 1930. Complete copy upon request.*

2. L. H. Hill, A. I. E. E. TRANS., Vol. XLVI, 1927, p. 582.

1. Induction regulators are generally used on low-voltage distribution circuits of small capacity.

2. The parallel winding method is now obsolete because (a) it is not economical from the design point of view; (b) the multiplicity of taps usually makes it necessary to place part of the mechanism inside the case; (c) it requires a complicated sequence of operations; and




| SEQUENCE OF TAP CHANGING. | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POSITIONS | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | |
| % VOLTAGE | 100 | | 97½ | | 95 | | 92½ | | 90 | | 87½ | | 85 | | 82½ | | 80 | |
| C.B. #1 | O | O | O | | | | | | | | | | | | | | | |
| " #2 | | | O | O | O | O | O | | | | | | | | | | | |
| " #3 | | | | | | | O | O | O | O | O | | | | | | | |
| " #4 | | | | | | | | | | | O | O | O | O | O | | | |
| " #5 | | | | | | | | | | | | | | | O | O | O | |
| C.B #6 | O | | | | O | | | | O | | | | O | | | | O | |

O = SWITCH CLOSED.

FIG. 5—DEVELOPMENT OF TRANSFORMER WINDING SHOWING TAPS, ARRANGEMENT OF SWITCHES, BRIDGING AUTO-TRANSFORMER, AND SEQUENCE CHART FOR THE SIMPLE SINGLE-WINDING METHOD OF TAP-CHANGING-UNDER-LOAD EQUIPMENT

(d) part of the winding is overloaded during transition periods.

3. One single-winding method which is an outgrowth of the parallel winding method is known as the multiple circuit method. The principal difference between this and the parallel-winding method is that

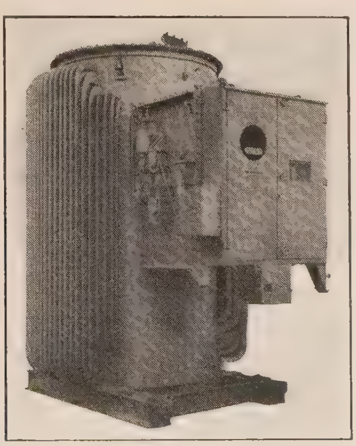


FIG. 6—FRONT ELEVATION VIEW OF TRANSFORMER WITH THE TYPE "UB" TAP-CHANGING EQUIPMENT

instead of two parallel windings, a multiplicity of double taps on a single winding is used. Also, a separate auto-transformer is used during the transition period to control the circulating current, whereas in the parallel-winding method the inherent impedance between the two windings served this purpose.[3]

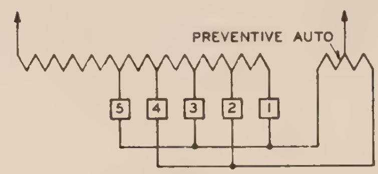
3. L. F. Blume, *General Elec. Rev.*, March, 1928, p. 123.

A simpler single-winding method which is later described is shown schematically in Fig. 5.

The single-winding method has outlived the parallel-winding method and is now being used by all leading manufacturers. As a consequence, this paper deals principally with the single-winding method of tap changing and describes the equipment involved, in which every opportunity for simplicity in design has been used.

The simplest method of changing the voltage ratio of a transformer is to provide taps in the transformer winding and a bridging auto-transformer to be switched along the taps as is shown in Fig. 5. A range of 10 per cent voltage above and below normal, each in four steps, is obtained with this simple arrangement.

To obtain the full winding of the transformer in the circuit, (Fig. 5), switches 1 and 6 are closed. The circuit is then through the full transformer winding and divides through the preventive auto-transformer, one-half being




| SEQUENCE OF TAP CHANGING | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| POSITIONS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| SW - 1 | O | O | | | | | | | |
| 2 | | O | O | O | | | | | |
| 3 | | | | O | O | O | | | |
| 4 | | | | | | O | O | O | |
| 5 | | | | | | | | O | O |

O = SWITCH CLOSED

FIG. 8—DEVELOPMENT OF TRANSFORMER WINDING AND SEQUENCE CHART FOR SINGLE-WINDING METHOD OF TAP-CHANGING-UNDER-LOAD EQUIPMENT IN ITS SIMPLEST FORM

through one side of the auto-transformer and one-half being through the other side in the opposite direction. The voltage of the transformer is therefore the voltage induced in the entire winding. To change taps one step, switch 6 is opened and 2 is closed. This connects the auto-transformer across the two taps, and since the line lead is attached to the center of the preventive auto-transformer, the line voltage comes the same as it would have been had the line lead been attached to a tap midway between the two actually brought out.

Similarly, to change taps still further, the process is completed in the same manner as indicated in sequence of tap changing in Fig. 5. This method of switching produces the whole range of nine voltage ratios with only five tap leads and six switches. Each operating position is equivalent to an exact tap position. Figs. 6 and 7 show front and side elevation views of a transformer with this single winding method of tap-changing-under-load equipment.

Fig. 8 is a schematic diagram of a further simplification of the single winding method of tap changing under load with a bridging auto specially designed to meet two different operating conditions. When it bridges across two taps, it operates simply as an auto-transformer.

On the alternate tap positions half its winding is connected in series with a tap from the transformer winding and it functions as a reactor. Under the latter condition, it introduces into the circuit a small out-of-phase voltage vector. The special design features of the auto-transformer are devoted to keeping its voltage low when it acts as a reactor. At 100 per cent power factor this vector has no measurable effect on the voltage of the transformer because it is practically in quadrature. At lower power factors it has more effect because it swings around more nearly in phase with the delivered voltage. Its maximum effect would be at practically zero per cent power factor. With power factors that are found in service, the reactor effect of the auto-transformer is of no practical importance.

The switches, operating cams, driving motor, and other parts that make up the complete tap changer

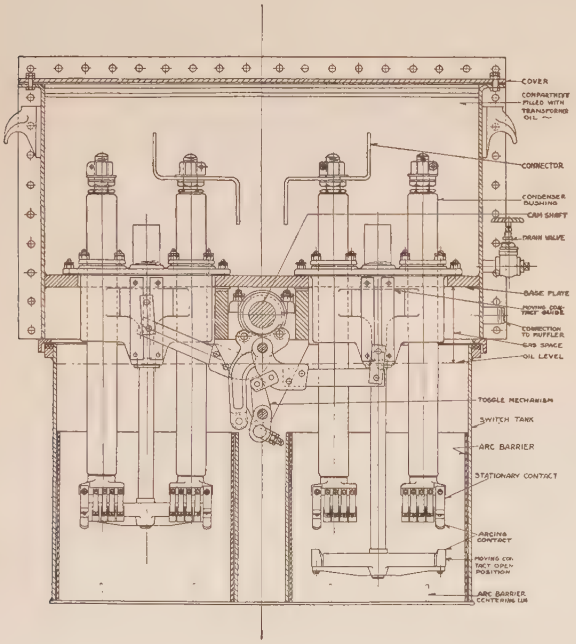



Fig. 9—Cross-section Elevation of the Type "UB" Tap-Changing Equipment

shown in Figs. 6 and 7, are all placed together in a housing mounted upon the side wall of the transformer case. The tap leads from the transformer winding pass directly through the tank wall into this housing, where they connect to the switches. The compartment enclosing these leads and connections is oil filled, and the switches themselves operate in oil.

In the development of tap-changing-under-load equipment, it was found much better, as a means of simplifying the scheme of connections and operation, to place all parts of it outside the transformer case. Power transformers as they are built at present are at best rather complicated affairs, and keeping mechanisms and moving parts out of the main transformer case helps considerably in the effort to keep them as free from complications as possible. With the type shown, only a few leads need be carried through the tank wall. The net result of the combination of transformer and tap changer is one that represents the utmost simplicity and reliability. A cross-section drawing illustrating the arrangement of the switches and the mechanism that operates them from the cam shaft is shown in Fig. 9.

Like most tap changing equipments operative under load, the equipment is designed to be operated by motor

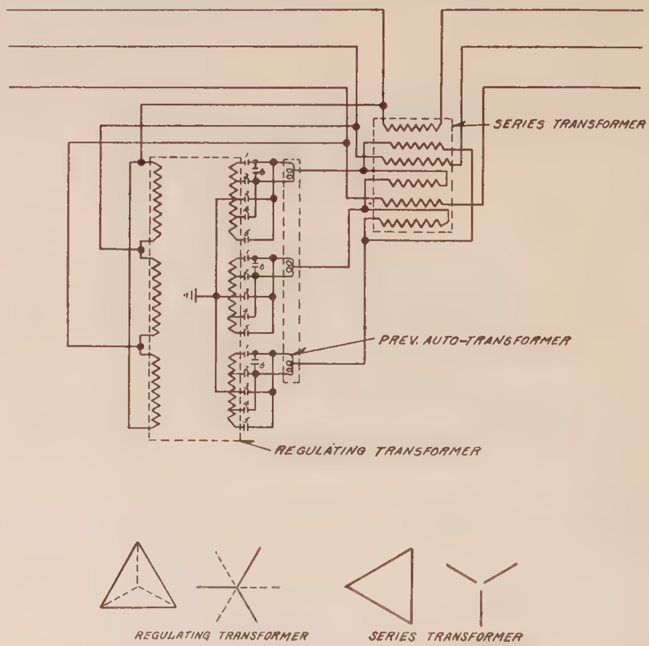



Fig. 11—Separate Two-Winding Regulating Transformer with "UB" Tap-Changing Equipment for Changing Taps under Load for Voltage Control

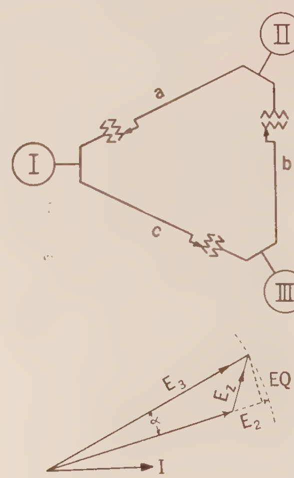



Fig. 12—Three Power Systems Interconnected to Form a Power Loop and Vector Diagram Showing the Conditions which Exist when the Line is Opened between Systems II and III

from a distance, but it can also be operated by hand when desired.

When the tap changer operates directly in the winding to be regulated the switches used for changing taps must be insulated for the voltage of the particular part of the winding in which they operate and be capable of carrying the winding current. Sometimes it is cheaper

to use a regulating transformer connected as shown in Fig. 11, with a rating of only the kv-a. of the control required. The voltage and current may be jointly adjusted to give the minimum switchgear cost. For transformers already installed, it is customary to use a tap changing equipment to vary the voltage of a separate regulating transformer in this manner. The regulating transformer may take the form of an auto,-or as a two-winding transformer as shown in Fig. 11. The adjustable voltage is applied to a series transformer

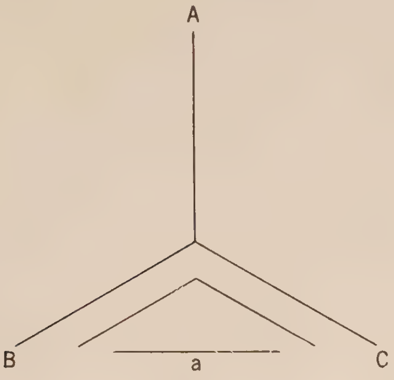



FIG. 13

connected in the line whose voltage is to be regulated. The principle of changing taps and the equipment are the same as used for new transformers built for the purpose.

### PHASE-ANGLE CONTROL

If one of two interconnected power systems is in turn connected to a third power system without forming a closed loop, the problem is still one of voltage control because the division of actual load is controlled through governor speed adjustments.

If two or more interconnected systems or parts of one system form a closed loop, (Fig. 12), conditions arise which cannot be corrected simply by voltage control and by governor adjustments. The governors in each generating station can be adjusted to control the power output from that particular station. The closed power loop, however, forms two paths between a generating station and the load at points around the loop. The tap-changing-under-load voltage control equipment can be adjusted to obtain voltages of equal magnitude at a particular location in the power loop, but these voltages may not necessarily be in phase. For example, if the line is opened between stations II and III, Fig. 12, and the voltage $E_3$ is measured on the station III side and the voltage $E_2$ is measured on the station II side, there may be a voltage $E_z$ between $E_2$ and $E_3$ across the open breakers. The dotted extension of $E_2$ indicates how the voltages can be adjusted to equal magnitude by means of tap-changing-under-load equipment for voltage control only, but a quadrature voltage $E_Q$ still exists across the breaker, because $E_2$ and $E_3$ are not in phase. If the tie line be connected to form a closed ring, current would flow from $E_2$, the line with leading voltage, to $E_3$, the line with lagging voltage.

If a voltage in quadrature with one of these delivered voltages, $E_2$ for example, is added in the line to compensate for $E_Q$, the two voltages $E_2$ and $E_3$ can be brought into phase with each other. The division of load can be adjusted between the two parallel paths of the loop by adding in-phase components and quadrature components of voltage to compensate for the impedance voltage in one of the parallel paths of the loop.

The voltage relations, of course, would change with a change of load. The added quadrature voltage should, therefore, be available in adjustable form.

A quadrature voltage may easily be obtained in a three-phase system with transformers. If voltages from phases $B$ and $C$ of the star-connected regulating winding in Fig. 13 are connected in series, the resultant voltage, $a$, will be displaced 90 deg. from the voltage of phase $A$. With suitable transformer connections it can be superimposed upon the voltage of phase $A$.

Equipment which has been developed for adjusting the voltage ratio of power transformers without inter-

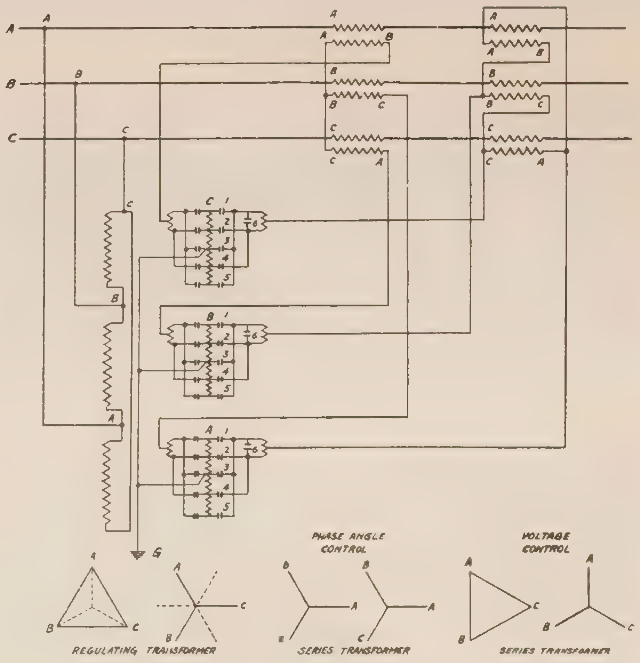



FIG. 17—SEPARATE TWO WINDING REGULATING TRANSFORMER WITH TWO "UB" TAP CHANGING EQUIPMENTS FOR COMBINED VOLTAGE AND PHASE-ANGLE CONTROL

rupting the load may be adapted to the control of phase angle without any modifications in the mechanism; it may be used for this purpose also without disturbing the continuous flow of power.

Voltage adjustment and phase-angle control may be combined in the same transformer. Separate switching mechanisms and separate series transformers are of course required in order to get the separate adjustments. Fig. 17 shows a typical scheme of connections for combined ratio and phase-angle control.

The greatest problem in connection with phase-angle control with static transformers is not the equipment, for it is available in simple and reliable form. It lies rather in the calculation of the amount of phase shift required to get the operation that is wanted for the varying conditions under which load is delivered. In the case of complicated interconnections with several generating stations and various load centers with variable distributions of load, it is not altogether a simple matter to determine just what shift of phase will produce the best net results.

It would seem that the static transformer with phase-angle control equipment will eventually occupy an important place in the progress of interconnections.

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**Abridgment of**

# Ionization Currents and the Breakdown of Insulation

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and

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***Synopsis.***—*Certain theories of the breakdown of gases are reviewed. Their limitations or correctness in the light of recent data on the breakdown of large gaps with surge voltages are considered. The work of various investigators on the time lag of breakdown also is discussed briefly. It is shown that comparisons are made difficult and that large discrepancies, particularly at the shorter time lags, may result from variations in the definitions of time lag and breakdown time.*

*The existence of ionization or streamer currents of high magnitude previous to the final breakdown is established and a number of volt—time and ampere—time oscillograms of flashovers on various types of insultation with the effect of these streamer currents in attenuating a traveling chopped wave are shown and discussed.*

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## Introduction

ONE of the most perplexing engineering problems is the application of insulation. Continually increasing voltages and higher temperatures, together with economic requirements, have necessitated extensive development and research programs for the study of the properties of insulating materials. In spite of much study and ceaseless effort, however, no exact indisputable law as for the performance of insulation have been discovered. From years of experience, empirical equations concerning particular applications have been formulated and it is upon these that the designer must rely. A more exact knowledge of the process of breakdown is of prime importance, since other properties of various types of insulation could then be established more readily and applied more effectively.

## Theories of the Breakdown of Air

The first theory to give a satisfactory explanation of the electrical breakdown of air was advanced by Townsend.[1] Briefly, this theory may be summarized as follows; upon the application of sufficient voltage, the free electrons in the field move toward the anode and are swept out of the field. During this movement, they collide with the molecules of the gas and produce new ions by collision. The newly created positive ions move toward the cathode, creating more new ions by collision, although the rate of ionization is much less than for the electrons. If the positive ions in their movement toward the cathode produce more electrons than were in the field originally, the discharge will become unstable;—that is, so long as a constant impressed voltage is maintained the current will continue to increase.

Two important conclusions may be drawn from this theory: First, breakdown takes place throughout the whole field simultaneously; second, the time of breakdown cannot be any shorter than that required for the movement of an electron from one electrode to the other and for the return movement of the positive ion. Although checked and proved experimentally at low pressures, at atmospheric pressures, (Townsend's theory appears inadequate). Rogowski[2] has shown that according to Townsend's theory the ionization process requires a time of the order of $10^{-5}$ sec., whereas experimenters[3,4] agree that with slight overvoltages, the spark lag may be as short as $10^{-8}$ sec. Suppressed discharges[5] show that breakdown does not take place simultaneously throughout the whole field. Actually, streamers form in the most intense parts of the field and these streamers cause breakdown by developing until the two electrodes are linked.

More recently, Slepian[6] presented a new theory which accounts for the steamer currents and according to which spark lags of the order of $10^{-7}$ sec. may be obtained with slight overvoltages. Slepian's theory may be summarized briefly as follows: Upon the application of suitable potential, free electrons in the field move toward the anode and multiply by collision. In forcing their way through the gas, the rapidly in-

*Both of Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

1. See Bibliography for all references.

*Presented at the Great Lakes District Meeting of the A. I. E. E., Chicago, Ill., December 2-4, 1929. Complete copy upon request.*

creasing electrons produce sufficient heat to cause thermal ionization and a streamer is formed. This sequence takes place in the most highly stressed parts of the field, which are usually at the electrode surfaces. Immediately upon the formation of the streamer, the gradient at its tip becomes very high, thus increasing its growth in the same manner in which it was formed. One end of the streamer becomes attached to the adjacent electrode; the other end develops at an increasing rate until the gap is spanned. When this occurs, the gap may be said to be broken down.

A conclusion which might be drawn from both of the above theories is that appreciable currents exist prior to complete breakdown. More specifically, these currents would be expected from the rapid space charge formation of Slepian's theory and from the ionic formation and migration of Townsend's theory. Slepian and Torok[7] have shown that such currents may amount to thousands of amperes in large homogeneous fields.

### Currents Preliminary to Breakdown

The magnitude of currents prior to breakdown as shown by Slepian and Torok was determined by sphere-gap measurements, and consequently only the crest values of the currents drawn by the streamers were obtained. Although this determination was far from complete quantitatively, since only the approximate form and the magnitude of the applied waves were known, it served to indicate the definiteness of extensive preliminary ionization. Since it introduces a new consideration which may help to solve some of the mysteries of the performance of insulation, this ionization is of vital importance from the standpoint of insulation research and application.

### Additional Streamer Current Work

The rapid development and application of the cathode ray oscillograph have made possible a more complete study of these preliminary currents. In this work a special adaptation of the oscillograph was necessary, however, since to obtain both current and voltage traces accurately upon the same film, a practically perfect reproduction of phenomena was essential. In this application, linear coordinates and a single sweep of the cathode ray across the film were considered most desirable. This required a method of synchronization whereby the cathode ray beam, a timing system, and the test potential were under close control. The final arrangement permitted the whole sequence to be repeated at will with a maximum time variation of one-fifth of a microsecond. Fig. 1A in which two successive traces superimpose upon each other, and Fig. 3C in which five applications at different voltages are recorded show how closely synchronism may be obtained. Thus, a single oscillograph was employed and the two traces which represent current and voltage were secured by consecutive voltage applications. It is realized fully that a two-element oscillograph, which at the present time would mean two separate cathode ray oscillographs, would meet the requirements of this application much better than a single instrument, and work for this is under way. In the present case a slight variation of voltage on consecutive applications might appreciably change the magnitude of the resulting current; this

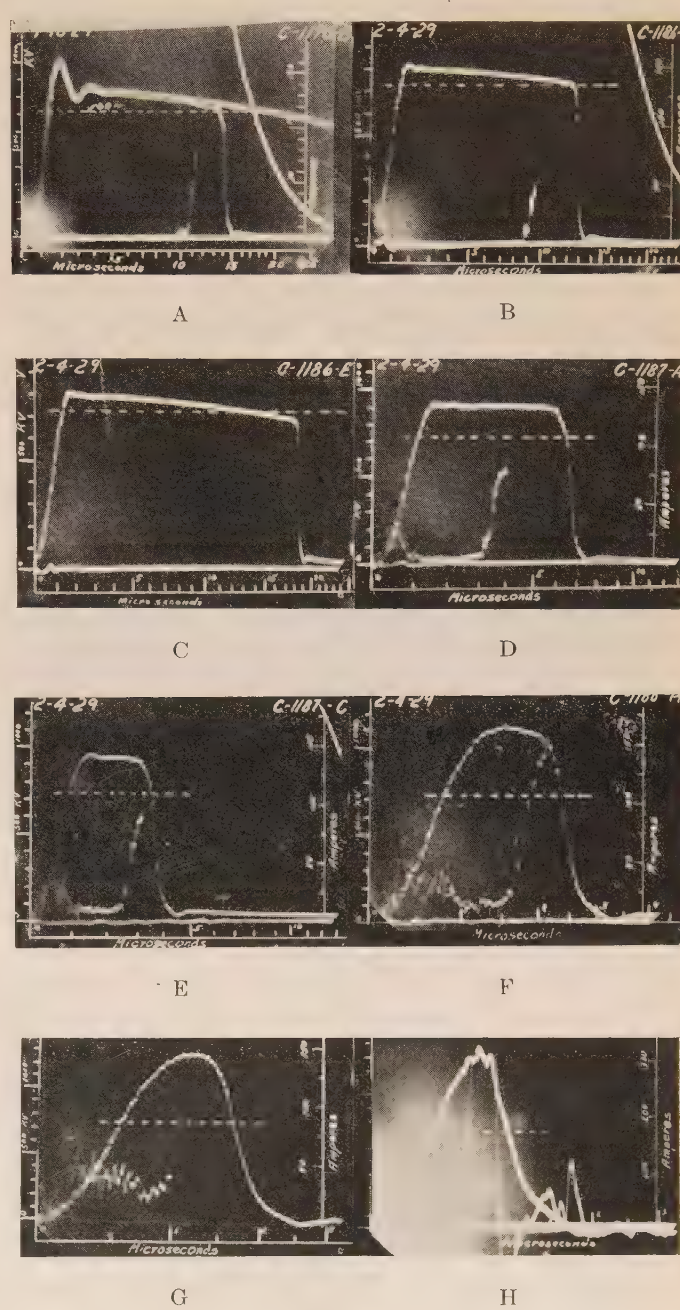



Fig. 1—Cathode Ray Oscillograms of Flashovers on Four Pillar Type Insulators

A The accuracy of the timing arrangement is shown by the manner in which successive voltage waves coincide perfectly up to the point where one resulted in flashover

B Current and voltage relations. Note the abrupt rise of the ionization current

C Completion of the flashover after the voltage dropped below the 60-cycle crest flashover value

D A marked reduction in time lag produced by a higher applied voltage

E The effect of further increasing the voltage is shown

F The streamer currents may be prominent before the crest of the wave is reached

G The phenomenon of F is more apparent here

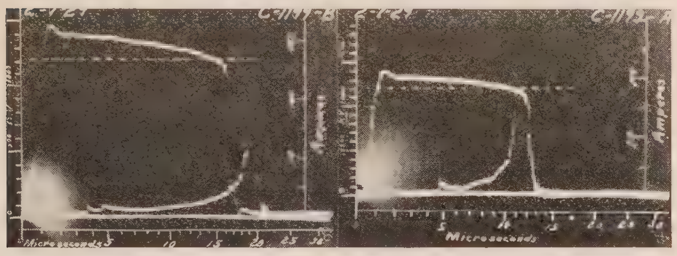
H Streamer currents limit the maximum voltage reached

possible error in the current was partially eliminated by averaging results from several oscillograms of each test condition.

The test procedure used to obtain time-lag oscillograms was in general the same for all tests. The voltage of the surge generator was regulated to a critical value barely sufficient to flash over the insulation. Several oscillograms were then obtained at this setting, after which the surge generator voltage was slightly raised and more oscillograms were taken. This procedure was continued until the voltage limit of the generator was reached. The voltage was reduced by a potentiometer and transmitted to the oscillograph through a cable to obtain the volt—time traces. Current was determined from the drop across a series resistor, and this drop was also transmitted to the oscillograph through a cable. The latter cable was protected against overvoltage by a small sphere-gap adjusted to break down on excessive currents.

## Discussion of Oscillograms

The current drawn by the apparatus under test is the resultant of two distinct components, the charging



A B

Fig. 2—Surge Flashovers of 16 Suspension Insulators

A Voltage and current relations
B Note the sudden rise and fall of current previous to the normal increase

current and the ionic current. These may be segregated by first determining the charging current from the recorded voltage wave and the capacity of the apparatus and graphically subtracting this current from the total. Unfortunately the majority of the apparatus tested and discussed herein has capacity sufficiently high to draw charging currents of 25 to 75 amperes, thus making the determination of small ionic currents unreliable during the charging period. Another method of obtaining the point at which extensive ionization occurs is to impress a flattopped wave of such a magnitude that ionic currents start only after the charging period is over. Identical results from these two methods cannot be expected, as the difference in the time involved is quite large. In one case appreciable steamer currents must develop in a few hundredths of a microsecond, whereas with the other method, the time for development is limited only by the ability of the generator to maintain the voltage.

A close examination of the oscillograms depicting long time lags on pillar type insulators, as shown in Fig. 1B, illustrates the abrupt start of the ionization current. This takes place after an interval of time which depends upon the amount of overvoltage above a critical value below which ionization currents of appreciable magnitude cannot be obtained. Fig. 1C shows a flashover which was completed after the voltage had fallen below the 60-cycle breakdown value. This may be explained

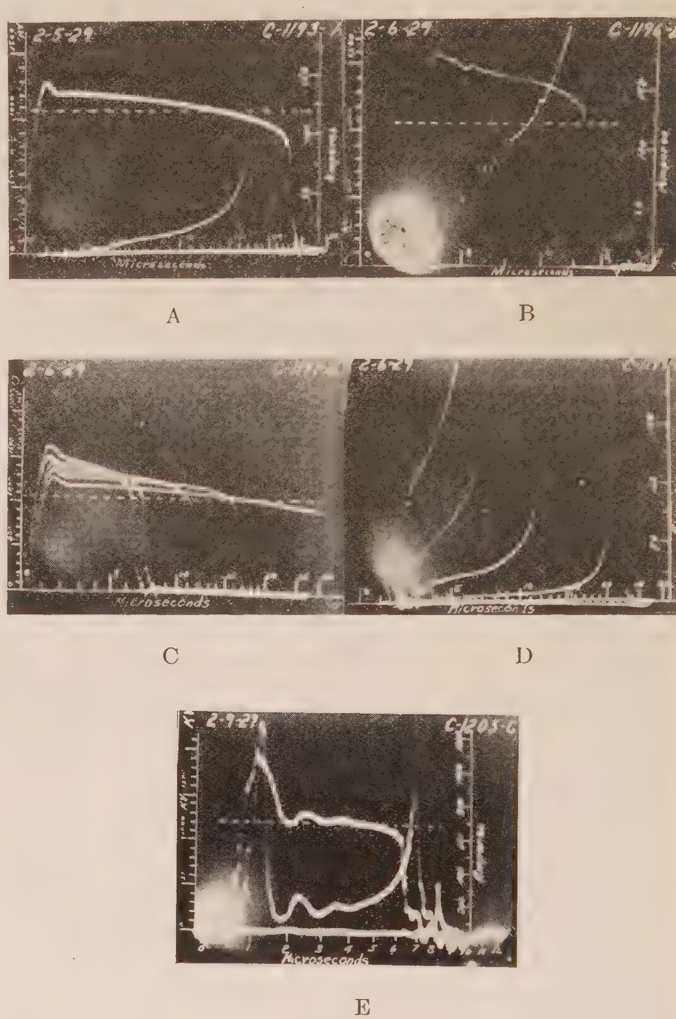


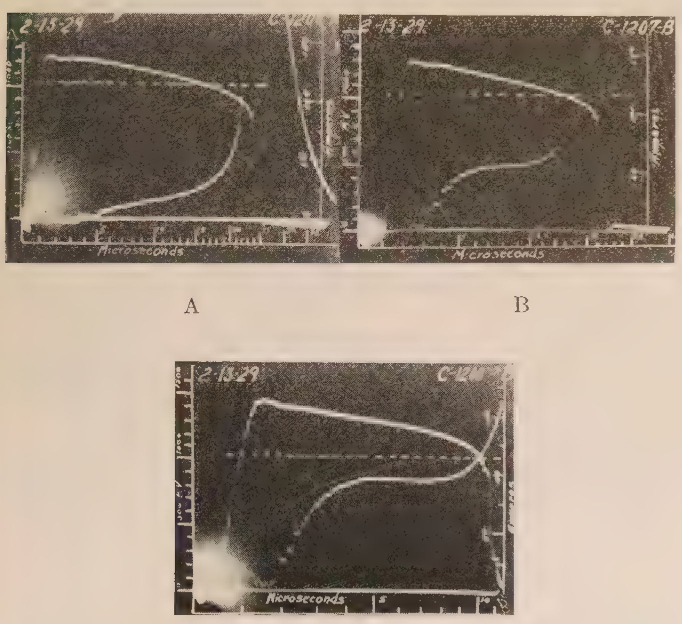
Fig. 3—Surge Flashovers on a 16-Unit Insulator String Equipped with Arcing Rings of Four-Inch Diameter Pipe

A Voltage and current relations
B The effect of increasing the voltage is shown
C Five successive applications at increasing voltage. The inverse relation between overvoltage and time lag is well illustrated
D The currents corresponding to (C)
E The response of the current to potential variation is shown

by the slow rate of formation of space charges and small streamers when the voltage barely exceeded the 60-cycle value. The formation of streamers decreased the effective spacing between the electrodes; this, together with the needle-gap properties of the streamers, raised the gradient to a value sufficient for the completion of breakdown. This point is substantiated by oscillograms on other apparatus, which follow. A slight increase in the applied voltage produces a marked reduction in time lag, as shown in Figs. 1D and 1E. In

Fig. 1G the streamer currents were very prominent even before the crest of the wave was reached. Fig. 1G shows this effect amplified still further, while in Fig. 1H the streamer currents were so large that the voltage wave was limited to 1350 kv. instead of reaching the voltage of the generator, which was 2000 kv.

Tests on a string of 16 suspension insulators showed similar breakdown characteristics, with the exception that at low voltages the current did not rise as abruptly—Fig. 2A. An interesting phenomenon is shown in Fig. 2B, where the current remained very low for several microseconds after the voltage reached its crest; then an abrupt rise and fall occurred, after which the current increased in a normal manner. It is probable that streamers were initiated at the time indicated by the first sudden rise in the current.




A B

C

Fig. 4—Surge Flashovers on 16 Suspension Insulator Units Equipped with Circular Arcing Rings of ¼-In. Strap

A Current and voltage relations with a slight overvoltage
B Current and voltage relations with a moderate overvoltage
C Current and voltage relations with a still higher overvoltage

Insulator strings equipped with arcing rings behave somewhat differently from plain strings under surge voltages. The nature of the arcing rings seems to determine almost entirely the resulting characteristics. Fig. 3A is an oscillogram of a flashover on a 16-unit string of insulators equipped with two arcing rings of four-inch pipe. Fig. 3B shows the corresponding current and voltage waves with moderate overvoltages. The start of the current wave was modified by high-frequency oscillations, (20,000 kilocycles), which were probably initiated by small rapidly forming streamers and thereafter maintained by leads which could not easily be eliminated. The effect of a variation of the applied voltage is shown in Fig. 3C where flashover occurred in all but one case. The corresponding currents appear in Fig. 3D.

Arcing rings of the strap type have somewhat different characteristics. Figs. 4A, 4B, and 4C, are typical oscillograms of the voltage and current waves. The flat portions of the current waves probably were caused by the decreasing voltage waves. In Fig. 3E, the voltage increased to a high value and then dropped to the 60-cycle flashover value. The large change in current caused by a relatively small potential variation shows clearly that the rate of ionization depends upon the overvoltage above a critical value. It follows also that the rate of ionization depends upon the nature of the stress distribution throughout the field.

In the breakdown of insulation, particularly of the gaseous form, ionization does not start at the time of the sudden reduction in voltage. The process may start 25 or 30 microseconds prior to the instant when the gas becomes highly conducting. In full consideration of this fact such terms as time lag and breakdown time become indefinite and arbitrary unless they are defined very completely. The rate of increase of current near the completion of flashover is so great that the voltage is abruptly reduced to a negligible value in a fraction of a microsecond. Thus, for breakdowns where the voltage remains at a high value for a considerable time,—that is, with long time lags,—variations in the determination of the breakdown point will be small in comparison. On the other hand, when breakdown occurs in a short time, as in Fig. 1G, these variations in the arbitrary points of the start of breakdown and the time of completion are such a large part of the surge duration that the results of different interpretations may deviate as much as 200 per cent.

## Attenuation

Klydonograph data obtained on transmission lines have shown that high-voltage surges which have caused flashover at some point of the line attenuate much more rapidly than low-voltage surges. This high rate of energy dissipation at high voltages is attributed commonly to corona on the line. However, with a chopped wave, which results when the line insulation breaks down on the front of a high overvoltage wave, streamers will form on the succeeding insulators and thereby produce high currents which will reduce the voltage much more rapidly than is possible with corona alone. The space charge and streamers that exist when the current is large invariably result in flashover unless the tail of the wave is abrupt or chopped.

## Conclusions

1. The process of breakdown of insulation on surge voltages does not start until the steady voltage breakdown value has been exceeded. Hence, it seems logical to compute time lag of breakdown from the first crossing of the steady breakdown value by the voltage wave instead of from the beginning of the wave.

2. After breakdown has started, ionization or streamer currents increase in magnitude as the streamers develop between the electrodes until the gap is

spanned, when the current limit is determined by the generator characteristics.

3. Apparently the magnitude of the streamer current at any time is a function of the amount of overvoltage above a critical value.

4. Streamer currents are indicative of an unstable condition, and therefore cannot be used for protective purposes except against chopped waves.

5. Streamer currents cause faster attenuation of high-voltage chopped waves than can be attributed to corona alone.

6. The rate and amount of energy dissipation prior to complete breakdown between two electrodes is a function of the nature of the electrostatic field.

7. Terms such as time lag, sparking time, and breakdown time are vague unless they are very completely defined. The time lag (as defined in this paper) of commercial apparatus values from $10^{-7}$ to $10^{-4}$ seconds.

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**Abridgment of**

# Air Transport Communication

BY R. L. JONES[1] and F. M. RYAN[1]

Member, A. I. E. E. Member, A. I. E. E.

***Synopsis.***—*The successful operation of an air transportation system depends in no small degree on the communication facilities at its command. Rapid and dependable communication between transport planes in flight and the ground is essential. Two-way radio telephony provides this necessary plane-to-ground contact.*

*The design of a radio telephone system for this service requires quantitative knowledge of the transmission conditions encountered in plane-to-ground communication. An experimental investigation of these conditions over the available frequency range has been carried out and the results are described.*

*A complete aircraft radio telephone system designed for the use of air transport lines and an airplane radio receiver designed for reception of government radio aids to air navigation are also described.*

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## Introduction

SAFETY and reliability with ships and trains depend to no small degree upon communication and signaling facilities. With the former, the radio telegraph conveys weather information and instruction. On the railroads, trains are dispatched by wire telephony and protected by electric signals. Airplanes represent another system of transportation, characterized by great speed and great dependence on the weather. The highest degree of reliability and speed is achieved only when instantaneous and direct means of communication with the ground are available to the pilot. This can best be provided by radio telephony.

## General Requirements

The requirements for radio apparatus for aircraft are particularly stringent. Principal among them are reliability and simplicity of operation. In mail planes and in some transport planes the most important apparatus elements must be installed in locations which are inaccessible during flight. With the small receiving antenna available, the equipment must be unusually sensitive and, at the same time, the receiver must be capable of delivering a high output level so that the signals may be clearly audible over the noise of the engine, propeller, and wind. High noise level is also an important and difficult factor in determining the design of microphones and receivers.

The use of the radio places special requirements on the airplane. The usual ignition system is the source of such violent electrical disturbances as practically to preclude the reception of radio signals. Interference from this source is overcome by proper shielding of the ignition system. The electrical aspect of the problem is quite simple but the mechanical difficulties are numerous. Recent cooperative attacks on the problem by government departments and by radio, accessory, and engine manufacturers, have resulted in good progress and shielded ignition systems having electrical and mechanical characteristics equal, if not superior to unshielded systems, are being made commercially available.

## Transmission Tests

The principal airports along the airways of the United States are at an average spacing of about 200 mi.

1. Both of the Bell Telephone Laboratories, New York, N. Y.

*Presented at the Great Lakes District Meeting of the A. I. E. E., Chicago, Ill., Dec. 2-4, 1929. Complete copy upon request.*

A range of reliable transmission of about 100 mi., therefore, will provide facilities for contact between planes in flight and radio ground stations at the airports. The frequency band employed for broadcast service, —that is, 550 to 1500 kilocycles,— is well suited for transmission at this distance. These frequencies, however, are not available for aircraft communication and consideration must be given first to the available bands above and below this range.

The International Radio Telegraph Convention of 1927 allocated a frequency band of 315 to 350 kilocycles

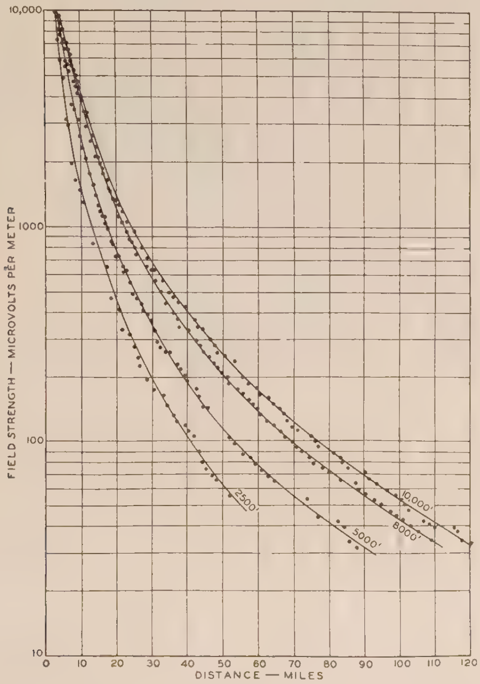



FIG. 4—STRENGTH OF DAYTIME SIGNALS RECEIVED IN AIRPLANE FROM 500-WATT GROUND STATION OPERATING AT 1510 KILOCYCLES

exclusively to air mobile service. This convention also allocated a number of other bands in the range 350 to 550 kilocycles to general mobile service. These bands have good transmission characteristics but a limited number of channels, and they have the further disadvantage of requiring a large transmitting antenna. A number of bands in the frequency range of 1500 to 6000 kilocycles was also allocated to mobile service. Further attention was directed to this range and experiments undertaken to determine its suitability for airplane radio telephone service.

For the conduct of these tests a cabin monoplane has been operated from Hadley Airport, New Jersey. Measurements of strength of received signals have been made both transmitting from plane to ground and vice versa. In the ground-to-plane experiments, a radio field strength measuring set was installed in the airplane. These transmission tests have been supplemented by similar flying tests made in California. Fig. 4 is a record of the strength of signals received from a 500-watt transmitter at Whippany, New Jersey, operating at a frequency of 1510 kilocycles during daytime flights from Whippany south toward Philadelphia. The data of this figure, plotted with logarithmic spacing of the ordinates, show quite strikingly the improvement in signals with increasing altitude.

Fig. 7 shows that transmission from plane to ground has somewhat similar characteristics. The curves of this figure are typical of a series of daytime transmission tests made in California. The curve for each altitude is the result of averaging the data obtained in flights in three directions from Oakland Airport. For the plane-to-ground tests the airplane was equipped with a radio telephone transmitter having a carrier power of 50 watts and a quarter-wave trailing-wire antenna. During many of these tests the field strength measurements were supplemented by telephone intelligibility tests. Lists of 25 disconnected words were read into the transmitter and a corresponding record made at the receiving end of the circuit.

From these studies and from other experience, it has

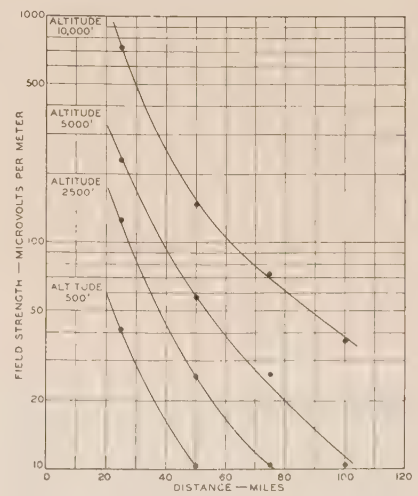



FIG. 7—AVERAGE STRENGTH OF SIGNALS RECEIVED FROM AN AIRPLANE EMPLOYING A 50-WATT RADIO TRANSMITTER—DAYLIGHT TRANSMISSION—FREQUENCY 3450 KILOCYCLES

been concluded that in the frequency band 1500 to 6000 kilocycles, satisfactory channels can be found for a radio telephone system to meet the needs of domestic air transport. The lower frequencies of the band appear to provide the most satisfactory transmission. The use of these frequencies is practical, however, only with trailing wire antennas. In order to avoid the mechanical disadvantages of the trailing wire, it may be desirable to use the higher frequencies of the band with fixed antennas of smaller dimensions. This would restrict the range of communication somewhat, but might offer a satisfactory solution if ground stations were located at sufficiently frequent intervals along the airways.

The 1500 to 6000 kilocycle band is not suited to direction-finding purposes over considerable distances. In general, it is necessary to use moderately low fre-

quencies for this purpose and the Department of Commerce has therefore adopted for airway radio beacons the band of frequencies internationally allocated exclusively to radio beacon service, 285 to 315 kilocycles. Weather information is usually broadcast in the adjacent exclusive aircraft band, 315 to 350 kilocycles.

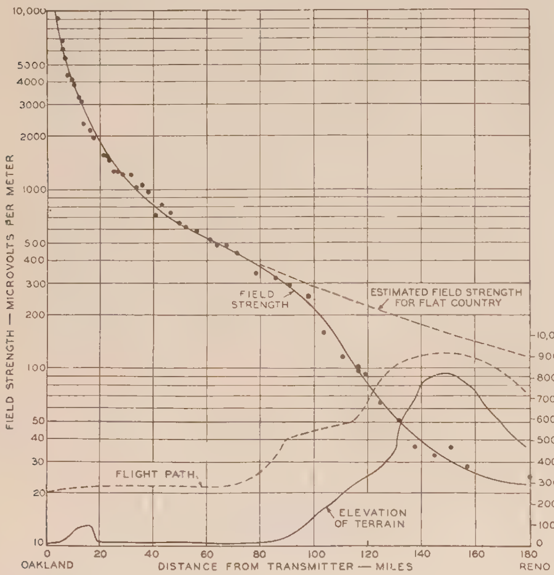



Fig. 14—Signal Strength in Airplane—Receiving from 500-Watt 325-Kilocycle Ground Transmitter

The problem of the radio manufacturer, therefore, is to provide a weather and beacon receiver for this service and along with it a two-way system to operate at the higher frequencies which have been referred to.

To provide information as to the signal strength that

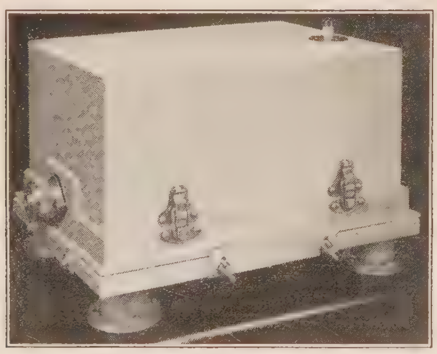


Fig. 20—High-Frequency Remote Controlled Aircraft Radio Receiver for Two-Way Communication

would be available at the frequencies of the weather and beacon stations a number of transmission tests has been made with the frequencies in this band. In this range little variation in signal strength is found with change of altitude. Changes of terrain, however, have considerable effect. Fig. 14 shows the attenuation of the signal introduced by the presence of a mountain range in a flight from Oakland, California to Reno, Nevada. The signals were transmitted from a 500-watt transmitter at Oakland Airport.

## Airplane Radio Receivers

Two airplane radio receivers have been developed which are similar in general design,—one with a frequency range of 250 to 500 kilocycles for beacon and weather broadcast reception and one with a range of 1500 to 6000 kilocycles for two-way communications. The circuit arrangement of each includes three radio frequency stages, a detector stage, and a stage of audio frequency amplification. The first radio frequency or

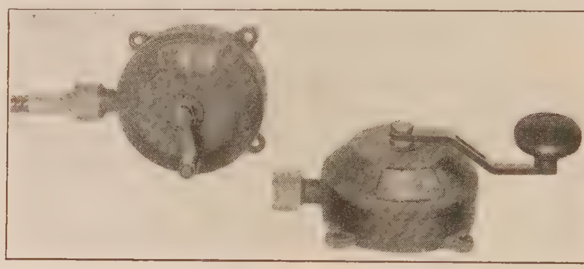


Fig. 22—Remote Tuning Control for Aircraft Radio Receivers

input stage is not tuned to the carrier frequency to be received but is provided with an input filter to avoid interference from unwanted stations, which sometimes results from modulation in such untuned amplifiers. Equipotential cathode vacuum tubes are employed throughout both receivers. Heating the cathode indirectly from an auxiliary filament avoids the possibility of introducing noise from the filament supply source.

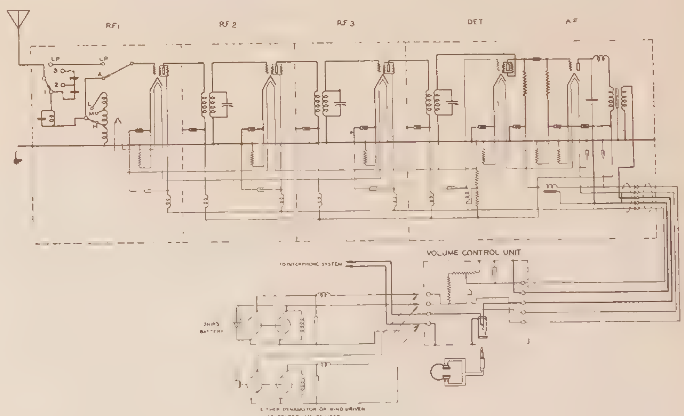



Fig. 23—Schematic Circuit of High-Frequency Aircraft Radio Receiver

Five tubes are used in each receiver, four are of the shield grid type, three being employed as radio frequency amplifiers and the fourth as a detector. The fifth does not contain a shield grid and is employed in the audio frequency amplifier. There are three tuned circuits,—one for the output of each stage of radio frequency amplification. A special gang condenser tunes all three simultaneously. The amplification of the receiver is controlled by a potentiometer which varies the shield potential of the radio frequency amplifier tubes. Both receivers are of high sensitivity. For example, with the low frequency receiver used for

weather and beacon signals, an antenna input of five microvolts is sufficient to deliver an audio frequency output of six milliwatts. For remote control, these receivers are arranged so that tuning can be accomplished by the use of a flexible shaft operating at a ratio of 264 times that of the condenser shaft. The radio receiver may be located 35 or 40 ft. from the pilot and tuning accomplished with practically no backlash. Remote volume control is arranged for by mounting the potentiometer

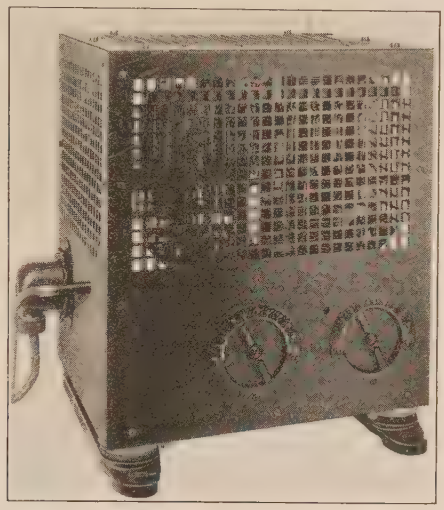


Fig. 24—High-Frequency Aircraft Radio Transmitter for Two-Way Communication

which controls the shield grid potential of the radio frequency amplifiers in a small unit located within easy reach of the pilot.

Figs. 20 and 22 show this design of radio receiver and Fig. 23 shows schematically the circuit of the high-frequency model.

## Airplane Radio Transmitter

An airplane radio transmitter has been developed

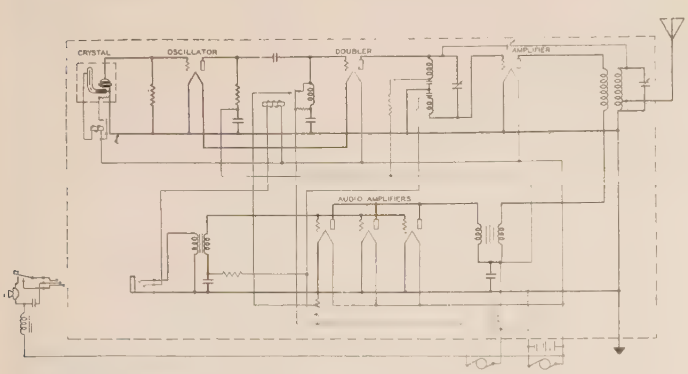



Fig. 26—Schematic Circuit of High-Frequency Aircraft Radio Transmitter

having a rating of 50 watts and capable of complete modulation. This power was chosen since the transmission tests showed it to be ample and a transmitter of this capacity could be made which would be of reasonable size and weight. Moreover, the power supply requirements are sufficiently moderate to be furnished in most present-day planes. The transmitter may be adjusted to any point in the range from 1500 to 6000 kilocycles and, being crystal controlled, it has a very high degree of frequency stability. The crystal controls the frequency of

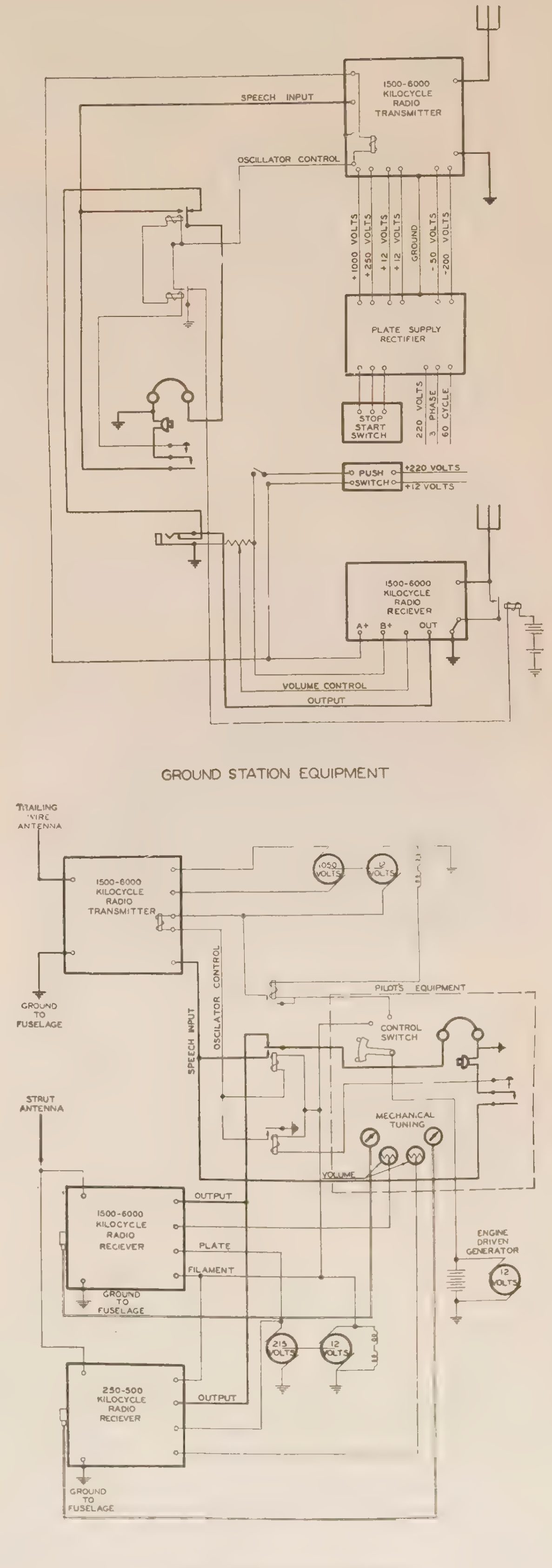



Fig. 27—Diagram Showing Equipment of Airplane and Ground Stations for Two-Way Communication

oscillation of a five watt tube. Its thickness is such that these oscillations have half the radiation frequency. A second five-watt tube is employed as a frequency doubler. The output of the doubler tube is impressed on the grid circuit of a final stage which is a fifty-watt radio frequency amplifier. This stage is neutralized and plate-circuit modulation is employed. The speech frequency circuit consists of the airplane microphone which is connected through an appropriate transformer to the grid circuits of three 50-watt tubes connected in parallel. The transfer of the voice frequency power from this amplifier to the plate circuit of the radio frequency amplifier is through a transformer designed to fit the impedance of the load circuit. The transmitter measures about 9 in. by 12 in. by 15 in. and weighs, complete with crystal unit and vacuum tubes, about 32 lb. The transmitter is shown in Fig. 24 and its circuit in Fig. 26.

### Ground Station

The ground station contains the apparatus which makes up the fixed terminal of the communication link

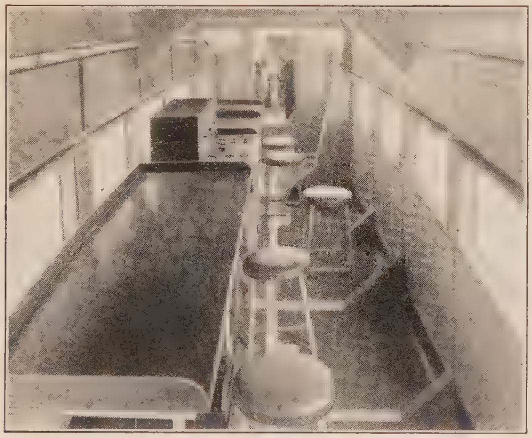


Fig. 33—Interior of New Transport Plane

with the airplane in flight. In general, its design follows conventional radio engineering practises and for that reason this paper refers to it much more briefly than to the airplane terminal.

The radio receiver is practically identical in fundamental design with the high-frequency receiver for airplane use, which has already been described. A special radio telephone transmitter has been developed for ground stations. This transmitter has a carrier power output of 400 watts and is capable of complete modulation. A single radiation-cooled vacuum tube is employed in its output stage. It may be adjusted to any frequency from 1500 to 6000 kilocycles and is provided with crystal frequency control similar to that employed in the airplane radio transmitter. The power supply for the plate circuit of this transmitter is ordinarily obtained from a three-phase rectifier employing tubes of the hot-cathode mercury-vapor type.

### System Features

The plane terminal of the two-way telephone link is comprised principally of the radio receivers and transmitter described. It is to be noted that "push-button" operation is used. This appears to be desirable on account of the close juxtaposition of the apparatus on the plane and for conservation of frequencies. The high frequency system is so designed that the same carrier frequency may be used both for plane-to-ground and for ground-to-plane transmission.

Fig. 27 shows a schematic diagram of the airplane station. A master control switch having three points serves to control the power supply for the radio receivers and transmitter. In the first position everything is "off." In the second position the receivers are turned "on." This is the normal position while in flight. In this position the heater circuit of the quartz crystal chamber is closed so that the radio transmitter is ready for instant operation. The third position of the switch supplies power to the radio transmitter as well as to the receivers. In this position reception from either set is possible and at the same time everything is in readiness for transmission. However, no oscillations occur in the transmitter until the push-button is depressed. In some installations the push-button is on the microphone; in others it is located on the "stick" so that the pilot may operate it without removing his hand. During conversation, this button is pressed while talking and released while listening. Relays perform all of the necessary switching functions.

For power supply the airplane radio transmitter requires for its operation a direct current plate supply of 400 milliamperes at 1050 volts and a filament supply of about 15 amperes at 10 to 12 volts. A typical airplane installation employs a generator geared to the airplane engine, across which is floated a non-spillable storage battery. This generator has a rating of 50 amperes at 12 to 15 volts. The filaments of the transmitter are fed directly from this generator-battery combination and the plate supply obtained from a dynamotor operated from the same source. A similar dynamotor furnished the 215-volt plate supply for the two receivers.

While the apparatus described is now becoming available, there is much interesting work still to be done. Fig. 33 shows the inside of an all-metal tri-motored plane which is being used in this further work.

## FIFTIETH ANNIVERSARY OF MICHIGAN ENGINEERING SOCIETY

At the Fiftieth Anniversary of the founding of the Michigan Engineering Society, to be observed at the fourth engineering conference, University of Michigan, Ann Arbor, January 30-31, 1930, many eminent men will be heard.

Among the speakers will be Robert P. Lamont, Secretary of Commerce; Frank C. Emerson, Governor of Wyoming, and Dr. Alexander G. Ruthven, president of the University of Michigan. The general theme of the conference will be "The Engineer's Contribution to the Art of Living."

# The 1930 Winter Convention

## TIMELY TECHNICAL PAPERS, TRIPS AND ENTERTAINMENT ARE ON THIS EXCELLENT PROGRAM

Many of the newest developments and studies in electrical engineering will be discussed in the technical program of the coming Winter Convention of the Institute. This meeting, which promises to equal in interest any of the splendid Winter Conventions, will be held with headquarters in the Engineering Societies Building, New York, January 27 to 31.

In addition to the fine technical program there will be interesting inspection trips and enjoyable entertainment with a specially arranged program for the ladies.

**PROGRAM**

MONDAY, JANUARY 27

| | |
|---|---|
| 10:00 a. m. | Registration |
| 2:00 p. m. | Session on Protective Devices |
| 8:15 p. m. | Joint Session with Illuminating Engineering Society on Ultra Violet Radiation |

TUESDAY, JANUARY 28

| | |
|---|---|
| 10:00 a. m. | Session on Power System Planning |
| 2:00 p. m. | Session on Selected Subjects |
| 6:30 p. m. | Smoker with Entertainment |

WEDNESDAY, JANUARY 29

| | |
|---|---|
| 10:00 a. m. | Session on Lightning Investigations |
| 2:00 p. m. | Inspection Trips |
| 8:30 p. m. | Edison Medal Presentation and Lecture |

THURSDAY, JANUARY 30

| | |
|---|---|
| 10:00 a. m. | Session on Transoceanic Communication |
| 2:00 p. m. | Session on Welding |
| 2:00 p. m. | Session on Dielectrics |
| 7:30 p. m. | Dinner-Dance |

FRIDAY, JANUARY 31

| | |
|---|---|
| 10:00 a. m. | Session on Electrical Machinery |
| 2:00 p. m. | Session on Electrical Machinery |

**Ladies Program**

The Ladies Entertainment Committee has been busy planning for the visiting ladies' amusement and pleasure. It hopes there will be a large attendance. A special room has been provided as a meeting place—to register and become acquainted and to obtain any information desired.

Please register early for these events:

TUESDAY, JANUARY 28

| | |
|---|---|
| 10:00 a. m. | Trips to the Westinghouse Lighting Institute and the Homemaking Center |
| 4:00 to 6:00 p. m. | Tea at the Engineering Woman's Club 298 Lexington Ave. (near 37th Street) |

WEDNESDAY, JANUARY 29

| | |
|---|---|
| 2:00 p. m. | Bridge and Tea on board an ocean liner (Meet at Ladies Headquarters) |

THURSDAY, JANUARY 30

| | |
|---|---|
| 10:00 a. m. | A visit to the Roosevelt House where a special cinematographic delineation of the life of Roosevelt will be given (Meet at Ladies Headquarters) |
| 7:00 p. m. | Dinner Dance at the Hotel Astor |

**Live Technical Subjects**

Reports on the field investigations of lighting made during 1929 will form the basis for one of the ten technical sessions.

Power-system planning is the subject of another well arranged symposium.

Lightning arresters and circuit breakers are the topics of another session.

Transoceanic telephone service and submarine telegraphy are covered in a session devoted to communication developments.

Electrical machinery papers will be presented in two sessions, one of particular interest to operating engineers and the other dealing with design.

A session on ultra-violet radiation is scheduled for one evening.

Dieletrics is a subject to be treated in five papers.

Welding will be discussed in another session and another session will contain papers on magnetic units, induced voltages and cathode ray oscillographs.

A list of the individual papers to be presented is given elsewhere in this announcement.

**Trips**

Some of the most interesting engineering developments in and near New York City will be seen on the inspection trips.

Tickets must be secured in advance for all trips not later than 4.00 p. m. on the afternoon preceding the day in which the trips are to be taken. Tickets may be obtained at the Convention or reservations may be made by mail.

The number of tickets will be limited and all who wish to take trips should register and get tickets at an early date.

Trips which have been tentatively arranged for the afternoon of Wednesday, January 29, are as follows:

- Roseland Switching Station, Public Service Company of New Jersey
- Fokker Airplane factory
- Demonstrations of equipment at Bell Telephone Laboratories
- Sperry Gyroscope Co.
- Air Map Corporation of America
- Short-wave transatlantic telephone transmitting center of the American Telephone & Telegraph Co.
- Transatlantic cable terminal—International Telephone & Telegraph Co.

The following daily inspection trips are tentatively planned:

- Westinghouse Lighting Institute
- Chrysler Building and Vertical Distributing System
- Network switch exhibit
- Lithographing plant of National Process Co.
- Electrical Testing Laboratories
- Hudson Avenue Generating Station and Research Laboratories of the Brooklyn Edison Company
- East River Generating Station of New York Edison Co.
- Hell Gate Generating Station of United Electric Light & Power Co.
- Automatic Stations of New York Edison Co.

**Edison Medal Presentation**

The Edison Medal will be presented to this year's recipient, Professor Charles F. Scott, in the Engineering Auditorium on the evening of Wednesday, January 29.

### Lecture

A lecture on a subject of world-wide interest will be given on Wednesday evening, immediately following the presentation of the Edison Medal.

The speaker will be Dr. David M. Robinson, Professor of Archaeology at Johns Hopkins University. He will speak on *Discoveries in Olynthus*, describing some of the remains of former civilizations which have been unearthed in Macedonia.

### Smoker

A buffet dinner and a smoker will be held on Tuesday evening, January 28, in the Engineering Societies Building. Some of the best entertainers in the country will be presented. In order to allow more opportunity for congenial mixing with friends the buffet dinner will be served in advance of the entertainment program. Ample time will be allowed so that the meal may be eaten leisurely. Louis Sherry will serve the dinner. The charge will be $3.00 for dinner and smoker.

### Dinner Dance

The annual Winter Dinner Dance will be held as usual at the Hotel Astor on the evening of Thursday, January 30.

No Institute function gives more pleasure than this annual dinner dance with its combination of good friends, good food, and good music. Tickets will be $6.00 per person. Reservations may be made for tickets seating eight people.

### Reduced Railroad Rates

Reduced rates for railroad transportation will be available under the certificate plan to members and guests who attend the Convention. Under this plan only half fare need be paid on the return trip over the same route provided 250 certificates are deposited by members at the Registration Desk. The rates apply to all members who attend the Convention and to dependent members of their families.

Each member or guest should obtain a certificate when purchasing his one-way ticket to New York. He should explain to the ticket agent that he wishes the certificate authorized by the passenger associations for the Winter Convention of the Institute.

On arriving at the Convention the certificate should be deposited at the Registration Desk. Here it will be held for validation by a railroad representative and if 250 certificates are validated, the validated certificate will later be returned to the owner. By presenting the validated certificate when buying a return ticket only half fare will be charged.

Local ticket agents should be consulted regarding conditions affecting this plan, as it applies only within certain dates depending on the territory.

*Everyone* whose one-way fare is over 66 cents *should get a certificate* whether or not he intends to use it. By neglecting to do so he may deprive others of considerable saving.

### Register in Advance

Each member will save time for himself and the committee in charge if he will register in advance by mail.

### Committees

The 1930 Winter Convention Committee is a follows: H. P. Charlesworth, Chairman; J. B. Bassett, S. P. Grace, C. R. Jones, H. A. Kidder, G. L. Knight, E. B. Meyer, and C. E. Stephens.

The chairmen of the subcommittees are, respectively: *Entertainment*, J. B. Bassett; *Inspection Trips*, F. Zogbaum; *Dinner Dance*, C. R. Jones; *Smoker*, G. J. Read, and *Ladies' Entertainment*, Mrs. G. L. Knight.

### Hotel Reservations

Reservations for hotel rooms should be made in advance in order to secure satisfactory accommodations. Members should write directly to the hotels which they prefer.

### Technical Sessions

PROTECTIVE DEVICES

January 27, 2:00 p. m.

*Metal-Clad Switchgear at State Line Station*, A. M. Rossman, Sargent & Lundy, Inc.

*Development of the New Autovalve Arrester*, J. Slepian, R. Tanberg and C. E. Krause, Westinghouse Electric & Mfg. Co.

*Thyrite, A New Material for Lightning Arresters*, K. B. McEachron, General Electric Co.

*Extinction of a Long A-c. Arc*, J. Slepian, Westinghouse Electric & Mfg. Co.

*Use of Oil in Arc Rupturing with Special Referene to System Stability*, B. P. Baker and H. M. Wilcox, Westinghouse Electric & Mfg. Co.

ULTRA VIOLET RADIATION

Joint session with Illuminating Engineering Society

January 20, 8:15 p. m.

*Simulating Sunlight*, M. Luckiesh, National Lamp Works of General Electric Co.

*An Ultra Violet Light Meter*, H. C. Rentschler, Westinghouse Lamp Co.

POWER SYSTEM PLANNING

January 28, 10:00 a. m.

*System Connections and Interconnections in Chicago District*, G. M. Armbrust and T. G. Le Clair, Commonwealth Edison Co.

*Fundamental Plan of Power Supply in the Detroit District*, S. M. Dean, Detroit Edison Co.

*Fundamental Plan of Power Supply in the Philadelphia Area*, Raymond Bailey, Philadelphia Electric Co.

*Turbine-Governor Tests at Colfax Power Station*, T. C. Purcell and A. P. Hayward, Duquesne Light Co.

*Controlling Power Flow with Phase-Shifting Equipment*, W. J. Lyman, Duquesne Light Co.

SELECTED SUBJECTS

January 28, 2:00 p. m.

*The Units of the Magnetic Circuit*, A. E. Kennelly, Harvard University

*The Calculation of Induced Voltages in Metallic Conductors*, H. B. Dwight, Massachusetts Institute of Technology

*Induced Voltage of Electrical Machines*, L. V. Bewley, General Electric Co.

*Design and Application of a Cathode Ray Oscillograph with Norinder Relay*, O. Ackermann, Westinghouse Electric & Mfg. Co.

LIGHTNING INVESTIGATIONS

January 29, 10:00 a. m.

*Cathode Ray Oscillograph Studies of Lightning on Transmission Lines*, J. H. Cox and Edward Beck, Westinghouse Electric & Mfg. Co.

*Surge Characteristics of Insulators and Gaps*, J. J. Torok, Westinghouse Electric & Mfg. Co.

*Lightning Investigations on Lines of Public Service Electric & Gas Co.*, R. N. Conwell, Public Service Electric & Gas Co., and C. L. Fortescue, Westinghouse Electric & Mfg. Co.

*Lightning Voltages on Transmission Lines*, R. H. George, Purdue University, J. R. Eaton, Consumers Power Company

*Study of Traveling Waves on Transmission Lines with Artificial Lightning Surges*, K. B. McEachron and W. J. Rudge, General Electric Co., J. G. Hemstreet, Consumers Power Co.

*Lightning Investigation on 220-Kv. System of Pennsylvania Power and Light Co.*, Nicholas N. Smeloff, Penn Power & Light Co., A. L. Price, General Electric Co.

*Lightning Investigation on Ohio Power Co. System*, Philip Sporn, American Gas & Elec. Co., W. L. Lloyd, Jr., General Electric Co.

*Lightning Investigation on Transmission Lines*, W. W. Lewis and C. M. Foust, General Electric Company

In response to the great current interest in lightning investigation, opportunity is to be provided for a continuation through the afternoon of the discussion of these papers.

TRANSOCEANIC COMMUNICATION
January 30, 10:00 a. m.

*The Post-War Decade in Submarine Telegraphy*, I. S. Coggeshall, Western Union Telegraph Co.

*Transoceanic Telephone Service—General Aspects*, T. G. Miller, American Telephone & Telegraph Co.

*Short-Wave Radio Transocean Telephone Circuits*

(*a*) *Transmission Features of Short-Wave Radio Circuits*, Ralph Bown, American Telephone & Telegraph Co.

(*b*) *Technical Features of the New Short-Wave Radio Station of the Bell System*, A. A. Oswald, Bell Telephone Laboratories, Inc.

(*c*) *Plan and Construction of Short-Wave Radio Systems*, F. A. Cowan, American Telephone & Telegraph Co.

WELDING
January 30, 2:00 p. m.

*Cathode Energy of the Iron Arc*, G. E. Doan, Lehigh Univ.

*Calorimetric Study of the Arc*, P. P. Alexander, General Electric Co.

*Resistance Welding*, B. T. Mottinger, Federal Machine & Welder Co.

*Electrically Welded Structures under Dynamic Stress*, Morris Stone and J. G. Ritter, Westinghouse Electric & Mfg. Co.

*Welding with the Carbon Arc*, J. C. Lincoln, Lincoln Electric Co.

DIELECTRICS
January 30, 2:00 p. m.

*Conductivity of Insulating Oils*, J. B. Whitehead and R. M. Marvin, Johns Hopkins University

*Behavior of Dielectrics*, R. R. Benedict, University of Wisconsin

*Three Regions of Dielectric Breakdown*, P. H. Moon and A. S. Norcross, Massachusetts Institute of Technology

*Ionization Studies in Paper-Insulated Cables—III*, C. L. Dawes and P. H. Humphries, Harvard Engineering School

*High-Voltage Corona in Air*, S. K. Waldorf, Johns Hopkins University

ELECTRICAL MACHINERY
January 31, 10:00 a. m.

*Loading Transformers by Temperature*, V. M. Montsinger, General Electric Co.

*Recommendations for Safe Loading of Transformers by Temperature*, W. M. Dann, Westinghouse Electric & Mfg. Co.

*Tap Changing Under Load for Voltage and Phase-Angle Control*, H. B. West, Westinghouse Electric & Mfg. Co.

*Telephone Interference from A-c. Generators Feeding Directly on Line with Neutral Grounded*, J. J. Smith, General Electric Co.

*Inversion Currents and Voltages in Autotransformers*, A. Boyajian, General Electric Co.

ELECTRICAL MACHINERY
January 31, 2:00 p. m.

*Generalized Theory of Electrical Machinery*, Gabriel Kron, Lincoln Electric Co.

*Quiet Induction Motors*, L. E. Hildebrand, General Electric Co.

*Transient Torque-Angle Characteristics of Synchronous Machines*, W. V. Lyons and H. E. Edgerton, Massachusetts Institute of Technology

*Starting Performance of Salient-Pole Synchronous Machines*, T. M. Linville, General Electric Co.

*Ventilation of Revolving-Field Salient-Pole Alternators*, C. J. Fechheimer, Westinghouse Electric & Mfg. Co.

*Synchronous Machines, V, (Three-Phase Short Circuit)*, R. E. Doherty and C. A. Nickle, General Electric Co.

## A. I. E. E. Nominations

The National Nominating Committee of the Institute met at Institute headquarters, New York, December 6, and selected a complete official ticket of candidates for the Institute offices that will become vacant August 1, 1930.

The committee consists of fifteen members, one selected by the executive committee of each of the ten Geographical Districts, and the remaining five elected by the Board of Directors from its own membership.

The following members of the committee were present: W. L. Amos, Toronto, Ont.; K. A. Auty, Chicago, Ill.; H. H. Barnes, New York, N. Y.; C. O. Bickelhaupt, Atlanta, Ga.; W. H. Colburn, Boston, Mass.; H. C. Don Carlos, Toronto, Ont.; H. S. Evans, Boulder, Colo.; Bancroft Gherardi, New York, N. Y.; J. E. Kearns, Chicago, Ill.; A. M. MacCutcheon, Cleveland, Ohio; George A. Mills, Dallas, Texas; H. H. Schoolfield, Portland, Ore.; C. E. Stephens, New York, N. Y.; G. W. Vinal, Washington, D. C.; and Assistant National Secretary H. H. Henline. Mr. B. Gherardi was unanimously elected chairman of the committee.

The following is a list of the official candidates:

FOR PRESIDENT

William S. Lee, Vice-President and Chief Engineer, Duke Power Company, Charlotte, N. C.

FOR VICE-PRESIDENTS

North Eastern District: I. E. Moultrop, Chief Engineer, Edison Electric Illuminating Company of Boston, Boston, Mass.

New York City District: H. P. Charlesworth, Vice-President, Bell Telephone Laboratories, Inc., New York, N. Y.

Great Lakes District: T. N. Lacy, Chief Engineer, Michigan Bell Telephone Company, Detroit, Michigan

South West District: G. C. Shaad, Dean, School of Engineering and Architecture, University of Kansas, Lawrence, Kansas.

North West District: H. V. Carpenter, Dean of Mechanic Arts and Engineering and Director of Engineering Experiment Station, State College of Washington, Pullman, Wash.

FOR DIRECTORS

A. B. Cooper, General Manager, Ferranti Electric Limited, Toronto, Ont.

A. E. Knowlton, Associate Professor of Electrical Engineering, Yale University, New Haven, Conn.

R. H. Tapscott, Electrical Engineer, New York Edison Company, New York, N. Y.

FOR TREASURER

George A. Hamilton, Elizabeth, N. J., (re-nominated).

The Constitution and By-laws of the Institute provide that the nominations made by the National Nominating Committee shall be published in the January issue of the Institute JOURNAL, and provision is made for independent nominations as indicated below:

CONSTITUTION

Sec. 31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the National Secretary when and as provided in the By-Laws; such petitions for the nomination of Vice-Presidents shall be signed only by members within the District concerned

BY-LAWS

Sec. 23. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with Article VI, Section 31 (Constitution), must be received by the Secretary of the National Nominating Committee not later than February 15 of each year, to be placed before that Committee for the inclusion in the ballot of such candidates as are eligible

On the ballot prepared by the National Nominating Committee in accordance with Article VI of the Constitution and sent by the National Secretary to all qualified voters during the first week in March of each

year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

National Nominating Committee
By F. L. Hutchinson,
Secretary.

## Biographical Sketches of Candidates

### FOR PRESIDENT

#### W. S. Lee

William States Lee was born in Lancaster, South Carolina, January 28, 1872, and was awarded the degree of C. E. by the Citadel, The Military College of South Carolina, in 1894; Honorary Degree of Doctor of Science, Davidson College, N. C., 1929.

Following his early engineering experience he was appointed Resident Engineer at the Anderson (S. C.) Light and Power Company in 1897; Resident Engineer of the Columbus (Ga.) Power Company in 1898, and Chief Engineer of the latter in March 1962. In March, 1903, he was appointed Chief Engineer and in October of that year Vice-President and Chief Engineer of the Catawba Power Company, Charlotte, N. C. This Company was a subsidiary of the Southern Power Company and in 1905 he became Chief Engineer of the latter company. He later received the appointment of Vice-President and Chief Engineer, which position he held for about fifteen years. He is at present Vice-President and Chief Engineer of the Duke Power Company.

Among Mr. Lee's other connections the following should be included: President of the W. S. Lee Engineering Corporation; President and Chief Engineer of the Piedmont and Northern Railway Company; Vice-President and Chief Engineer and Director, Duke Power Company, Wateree Power Company, Western Carolina Power Company, Catawba Manufacturing and Electric Power Company; Director, American Cyanamid Company; Vice-Chairman and Trustee of the Duke Endowment. He is also engaged in practise as a Consulting Engineer with offices in New York City and Charlotte, N. C.

He has been a pioneer in high voltage, hydroelectric power development and transmission, and is inventor of the Lee Pin. His Institute activities are as follows: Associate 1904, Member 1907, Fellow 1913, Director 1911-14 and 1929-, and member for several years of the Committee on Power Transmission and Distribution, Standards Committee, and Committee on Power Generation, being at present a member of the latter two and of the Edison Medal Committee.

Mr. Lee's other Society memberships include American Society of Mechanical Engineers, American Society of Civil Engineers, Engineering Institute of Canada, American Electrochemical Society, and the American Engineering Council.

### FOR VICE-PRESIDENTS

#### I. E. Moultrop

Irving E. Moultrop was born in Marlboro, Mass., July 24, 1865, and started his engineering career in 1882 by going with the Whittier Machinery Co. of Roxbury, Mass. as an apprentice in the machine shop. Following his apprentice term he went into the drafting room, and in due course was promoted to be head draftsman. He stayed until 1928 when he resigned to accept a position as engineer on mechanical construction work with the Boston Edison Company, and has been with the latter company ever since, advancing progressively to the position which he now holds, Chief Engineer of the Company. The Edgar Station, which is the latest generating plant of The Edison Electric Illuminating Company of Boston, was built by Stone & Webster, Inc., under the direct supervision of Mr. Moultrop.

He is at present a member of the A. S. M. E., A. I. E. E., Boston Society of Civil Engineers, N. E. L. A., American Standards Association, and the Association of Edison Illuminating Companies, as well as being one of the Vice Presidents of the American Engineering Council. He is at present a member of the Boiler Code Committee and the Committee on Power Test Codes of the A. S. M. E., and was on the Council of the A. S. M. E. for three years as manager and two years as Vice-President.

Probably the most important work that Mr. Moultrop has done for the A. S. M. E. was to serve as chairman of their Increase of Membership Committee for some five or six years, taking up this work when the Society had a membership of about 3000 and increasing that membership to nearly 7500, when he resigned to fill the position as a representative of the A. S. M. E. on the Board of Trustees of the United Engineering Society.

He is at present one of the Directors of the A. I. E. E., and has been a member of a number of the committees of this organization, at the present time serving as a member of the Committee on Power Generation. He has also served as Chairman of the Boston Section of the A. I. E. E.

Mr. Moultrop's prominence in the activities of the engineering work of the N. E. L. A. has been an outstanding feature of his career. He has served on the Prime Movers Committee, and the Steam Turbine and Gas Engineering Committee which preceded the Prime Movers Committee, some ten or twelve years, having been chairman of the Prime Movers Committee for some time, and also Chairman of the Technical Section, N. E. L. A., for three years.

At the present time Mr. Moultrop is President of the Engineers Club of Boston and President of the Woodland Golf Club, Auburndale, Mass. He is also a member of the Engineers Club of New York City and of the Mohawk Club of Schenectady, N. Y.

#### H. P. Charlesworth

After graduation by the Massachusetts Institute of Technology in 1905 with the degree of Bachelor of Science, Harry Prescott Charlesworth entered the Engineering Department of the American Telephone and Telegraph Company, then located in Boston. His early assignments had to do with the development of telephone circuits and associated apparatus. Later he was active for a number of years in the development of toll operating methods and the general related engineering problems involved in extending and improving telephone service.

With the opening of the war he was specially assigned to handle problems wherein the Bell System could be of assistance to the Government in the national emergency. In this capacity he was, throughout the war, active on communication facilities for army camps, naval bases, supply depots and particularly for the Government Departments at Washington, where he also assisted the Telephone Company on general equipment and traffic engineering matters.

Shortly after the close of the war he became for a short time Equipment and Transmission Engineer of the American Telephone and Telegraph Company, and in 1920 was appointed Plant Engineer of that Company, in which position he was concerned with all phases of the engineering of the telephone plant and with relations with other wire using companies. In December 1928 he was elected Vice President of Bell Telephone Laboratories, where he now directs operations involving more than five thousand people engaged in development, research and related activities pertaining to the communication art.

Mr. Charlesworth became a Member of the Institute in 1922 and a Fellow in 1928. He was Manager from 1924-1927, Chairman of the Meetings and Papers Committee from 1927-1929 and is now Chairman of the New York Section. He has served on many Institute committees, being at present a member of the Publication, Edison medal, Lamme Medal, Award of Institute Prizes, and Meetings and Papers Committees, and a representative upon the Alfred Noble Prize Committee and the Board of Trustees of United Engineering Society.

#### T. N. Lacy

Thomas Norman Lacy, Chief Engineer of the Michigan Bell Telephone Company, was born at Lititz, Pa., September 23, 1885. His early education was received in the public schools and Franklin and Marshall Academy. He was graduated from Lehigh University in 1906 with the degree of E. E.

After graduation he entered the employ of the American Telephone and Telegraph Company, Long Lines Department, at Philadelphia, Pa., and remained with that Department until 1925. Between 1906 and 1912 he occupied various positions in plant maintenance, engineering, and construction work in Philadelphia and New York. In 1912 he was appointed Division Plant Engineer for the Southern Division with headquarters at Atlanta, Ga., and in 1919 was appointed Division Plant Superintendent in the same division directing construction, engineering, and maintenance work. In 1925 he was transferred to the Michigan Bell Telephone Company and appointed Division Plant Superintendent at Detroit, Michigan. Since November 1925 he has been Chief Engineer of the Michigan Bell Telephone Company.

Mr. Lacy joined the Institute as a Member in 1924, and has been active in the Detroit-Ann Arbor section, serving as Secretary-Treasurer 1929-30 and serving as its representative on the Associated Technical Societies Council of Detroit.

#### G. C. Shaad

George Carl Shaad was born in Stratford, New York, May 5, 1878, of German parents. He secured the degree of Bachelor of Science in Electrical Engineering at the Pennsylvania State College in 1900 and the professional degree of Electrical Engineer was granted him by the same institution in 1905.

On graduation he entered the Testing Department of the General Electric Company, later transferring to the Switchboard Engineering Department of that Company where he remained until September of 1902. He was appointed instructor in Electrical Engineering at the University of Wisconsin in 1902 and taught in that institution until 1906, when he joined the teaching staff of the Electrical Engineering Department of the Massachusetts Institute of Technology as an assistant professor. In 1907 he was made an associate professor at M. I. T. When the electrical work at the University of Kansas was separated from the Department of Physics in 1909 he accepted the appointment as Professor of Electrical Engineering in charge of the department at that institution and he has retained his connection wtih the University of Kansas to date. He acted as Dean of the School of Engineering and Architecture and was in charge of the S. A. T. C. work in 1917-18. Since October, 1927, he has held the position of Dean of the School of Engineering and Architecture at the University of Kansas.

He has been employed in engineering work along with his teaching duties and acts in a consulting capacity in connection with engineering problems. In addition to local engineering organizations he is a member of the American Society of Mechanical Engineers and the Society for the Promotion of Engineering Education. He became an associate in the Institute in 1903, and transferred to the grade of Fellow in 1913. He has been associated with the work of Student Branches of the Institute since its beginning and for the past three years has been Student Branch Counselor delegate for the Seventh Geographical District. He has also served as chairman of the Kansas City Section.

#### H. V. Carpenter

Hubert Vinton Carpenter, Dean of Mechanic Arts and Engineering and Director of the Engineering Experiment Station at the State College of Washington, Pullman, was born near Mt. Carroll, Illinois, January 29, 1875. He was graduated from the University of Illinois with the degree of B. S. in Electrical Engineering in 1897, and received the degree of M. S. in Mathematics and Physics in 1899.

He served as assistant in Physics, University of Illinois, from 1897 to 1899 and as Instructor from 1899 to 1901. In January 1901, he became Assistant Professor of Physics and Electrical Engineering at the State College of Washington, and was appointed head of the Department of Mechanical and Electrical Engineering in 1903. Since 1917, he has held his present position as Dean of the College of Mechanic Arts and Engineering.

Dean Carpenter has contributed technical papers to the publications of the Institute, *Physical Review*, and other periodicals, and has made developments in electrical measuring instruments and also in water wheel regulating devices. He has won a high reputation as a teacher and an organizer of educational work.

Dean Carpenter joined the Institute in 1903, and was transferred to the grade of Fellow in 1918.

His other memberships include American Society of Mechanical Engineers (Member), Society for the Promotion of Engineering Education, American Association of University Professors, Tau Beta Pi, Phi Kappa Phi, and Theta Xi.

### FOR DIRECTORS

#### A. B. Cooper

Ashton B. Cooper was born in Bloomfield, Ontario, on December 31, 1883. After finishing at the local public grade schools he attended the Somerville Latin School at Somerville, Massachusetts, graduating subsequently from Tufts College in 1903 with the degree of B. S. in E. E.

After graduation Mr. Cooper spent two years in the General Electric Test Course at Schenectady. In 1906 he became Inspector for Dr. F. S. Pearson and was located at East Pittsburg in connection with the generating plant equipment then being manufactured by the Westinghouse Electric & Manufacturing Company for the Rio de Janeiro Tramway Light & Power Company. He was subsequently in Brazil for a year in connection with the installation of the same equipment.

In 1909 Mr. Cooper returned to the General Electric Company in the Transformer Sales Department, transferring in 1913 to the Canadian General Electric Company as Manager of the newly formed Transformer Sales Department.

Since 1922 he has been General Manager of Ferranti Electric Limited at Toronto.

Mr. Cooper joined the Institute as a Member in 1916, taking an active interest in the Toronto Section, of which he was Chairman in 1919-20. He was Vice-President of the Institute for District No. 10 for the term 1927-29, and has served as a member of the Lighting and Illumination, Membership, and Electrical Machinery committees.

Mr. Cooper has shown an active interest in local engineering affairs. He is a Past-President of the Engineers' Club of Toronto and of the Association of Profesional Engineers of Ontario. He is a member of the Engineering Institute of Canada and an associate member of the Institution of Electrical Engineers of Great Britain.

#### Archer E. Knowlton

Archer E. Knowlton is Associate Professor of Electrical Engineering at Yale University, and has been engaged in college teaching since 1910. He has also been Electrical Engineer of the Public Utilities Commission of Connecticut since 1911, has served on other governmental and professional society committees and has done general consulting engineering. On leave of absence from Yale during the remainder of the academic year he will be connected with the *Electrical World* as Associate Editor. He has been very active in Institute affairs since 1921 serving on Section, District and National Committees, at the present time being Chairman of the Meetings and Papers Committee.

Mr. Knowlton was born in New Haven, Conn., February 16, 1886. After grammar school and high school training, he attended Trinity College from which he received the degrees of B. S. in 1910 and M. S. in 1912. He attended Columbia University during the summer of 1911 and also took postgraduate work at Yale where he received the degree of E. E. in 1921.

He started teaching at Trinity College where he was Instructor in Mathematics and Physics from 1910 to 1914. He was Assistant Professor of Physics at the same institution from 1914 to

1919. He came to Yale University, in 1919, where he held positions in the Electrical Engineering Department as Instructor, Assistant Professor, and Associate Professor.

In addition to extensive work with the Public Utilities Commission of Connecticut from 1911 to date, Mr. Knowlton also served as Deputy Administrative Engineer of the U. S. Fuel Administration in 1918-1919 and on the Northeast Superpower Committee of the U. S. Department of Commerce in 1924.

He became a Member of the Institute in 1911 and has served as Secretary and Chairman of the Connecticut Section, as Chairman and member of the National Instruments and Measurements Committee, and as member of the national Meetings and Papers Committee of which he is now Chairman.

He is a member of the Society for the Promotion of Engineering Education and of Sigma Xi. He has served as technical advisor of the International Electrotechnical Commission, as member of technical divisions of the National Electric Light Association, on committees of the American Engineering Standards Committee and on the Connecticut Committee on Standardization of Electrical Practise.

He has contributed to the technical press many articles dealing with instruments and measurements, valuation, and other subjects.

**R. H. Tapscott**

Ralph H. Tapscott was born in Brooklyn, New York, August 31, 1885. After a preliminary education at Erasmus Hall Academy & Boys' High School, he entered business in the leather industry, which he left two years later to complete his education.

Upon graduation with the degree of B. S. in Electrical Engineering from Union College in 1909, he joined the Testing Department of the General Electric Company at Schenectady, transferring from there to the Lighting Engineering Department, where his duties largely involved work with the New York group of utilities.

On October 1917, Mr. Tapscott resigned from the General Electric Company to become Assistant Chief Electrical Engineer of The New York Edison Company, and in 1925 was made Electrical Engineer of that Company.

Mr. Tapscott joined the Institute in 1918, and has served as a member of the executive committee of the Standards Committee for a number of years, Electrical Machinery Committee one year, and Power Transmission & Distribution Committee two years. He has been a member of the Headquarters Committee since 1928. He also has just completed his term as chairman of the New York Section.

Among other societies, he was chairman of the Electrical Apparatus Committee of the N. E. L. A., and later a member of its Engineering National Committee, and is at present representing the light and power group as a member of the Electrical Advisory Committee.

FOR TREASURER

**George A. Hamilton**

George Anson Hamilton, a charter member of the Institute was born in Cleveland, Ohio, December 30, 1843. He early showed great interest in electricity.

In 1861, he became a messenger at Salem, Ohio, but two months later was made manager of the Atlantic and Great Western Railroad office at Ravenna. Illness forced him to relinquish this position in 1863, but upon his recovery he went to Pittsburgh as operator and manager of the Inland Company. In 1865, he became manager of the United States Telegraph Company's office at Franklin, Pa., but returned to Pittsburgh in 1866 as chief operator and circuit manager, and remained until 1873 when the Western Union Telegraph Company absorbed his company.

As assistant to Professor Moses G. Farmer of Boston, who was engaged in the manufacture of general electrical apparatus and machinery, he received valuable experience and participated in many important experiments and investigations in telegraphy and other electrical developments during the period 1873-75. In 1875, he became assistant electrician of the Western Union Telegraph Company in New York City. He participated in the establishment and maintenance of the first quadruplex telegraph circuits, and carried out experiments preliminary to establishing the Wheatstone high-speed automatic system in this country.

In 1889, he accepted a position with the Western Electric Company, being given supervision and care of the department for the production of fine electrical instruments, which position he retained until his retirement in 1909.

Mr. Hamilton was the first Vice-President of the Institute (1884-86), and has been its National Treasurer since 1895, and a Fellow since 1913. He has for many years been a member of the Edison Medal and Executive Committees. His other memberships include Institution of Electrical Engineers (Great Britain), Société Francaise des Electriciens, Société Francaise de Physique, and Société Belge d'Astronomie.

## International Congress in Liege

**TO CONSIDER RECENT WORK ON MINES, METALLURGY AND APPLIED GEOLOGY**

Plans are being made for the Sixth Session of the Congrès International des Mines, de la Métallurgie et de la Géologie Appliqué, which will be held in Liège, Belgium, June 22-28, 1930, during the International Exposition. Representatives highly qualified in science and industry will present results of their recent work at the sessions on Mines, Metallurgy, and Applications of Geology. Visits to the International Exposition will be included on the program.

## War Memorial Committee Discharged

The Committee on War Memorial to American Engineers has completed its long and arduous work and has presented a final report, copies of which have been transmitted to each of the sixteen participating organizations. The report contains a complete history of the Louvain Memorial, consisting of the carillon and clock in the Louvain Library, which was presented as a memorial to American engineers who gave their lives in the World War 1914-1918. It also describes the presentation ceremonies and includes letters of appreciation from the officers of the Louvain University.

At its own request the committee has been discharged by the United Engineering Society. Its members are to be highly congratulated upon the splendid success with which this very appropriate memorial has been completed. It will long remain a source of satisfaction to the members of the engineering societies, as well as to the people of Belgium.

## Power Generation Committee Desires Comments from Members

The power Generation Committee has appointed a subcommittee to investigate the question whether members of the Institute who are employed or connected with industries feel that their interests are being conserved by the reports issued by the Power Generation Committee or the papers presented for which the Committee is sponsor.

Any members who are interested in this matter should communicate with Frederick A. Scheffler, 85 Liberty Street, New York, N. Y.

It is the feeling of the Power Generation Committee that so far as possible the work of the Committee should be of help to all members of the Institute who are primarily interested in power generation.

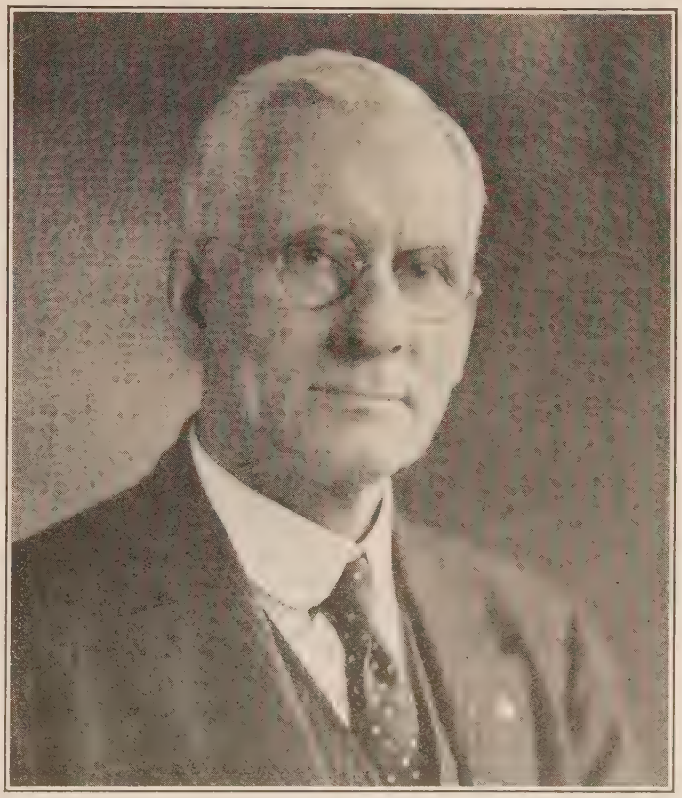
# Edison Medal Awarded to Charles F. Scott

## TO BE PRESENTED AT THE WINTER CONVENTION

The Edison Medal of the American Institute of Electrical Engineers has been awarded to Professor Charles F. Scott, New Haven, Conn., "for his contributions to the science and art of polyphase transmission of electrical energy." It is planned to present the medal to Professor Scott at a session of the Winter Convention, to be held on Wednesday evening, January 29.

The Edison Medal was founded by associates and friends of Mr. Thomas A. Edison, and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts," by a committee consisting of twenty-four members of the American Institute of Electrical Engineers.

The following men have been recipients of the medal: Elihu Thomson, Frank J. Sprague, George Westinghouse, William Stanley, Charles F. Brush, Alexander Graham Bell, Nikola Tesla, John J. Carty, Benjamin G. Lamme, W. L. R. Emmet, Michael I. Pupin, Cummings C. Chesney, Robert A. Millikan, John W. Lieb, John White Howell, Harris J. Ryan, William D. Coolidge, and Frank B. Jewett.



Charles F. Scott

Charles F. Scott, Professor of Electrical Engineering at Yale University, was born at Athens, Ohio, September 19, 1864. His collegiate education was received at Ohio University in Athens, the Ohio State University, Columbus, from which he graduated in 1885, and Johns Hopkins University, where he engaged in graduate study for about one and one-half years, at the same time teaching in the Baltimore and Ohio Railroad apprentice school.

In 1888, he entered the Testing Department of the Westinghouse Electric and Manufacturing Company. After acquiring experience in the dynamo room, the laboratory, and the development of alternating current motors, he became Assistant Electrician, and in 1897 was appointed Chief Electrician. In 1904 he was made Consulting Engineer of the company, and in 1911 was appointed to his present position at Yale University.

During his connection with the Westinghouse Company, he was a pioneer in high-voltage transmission of power and in the development of several types of equipment including induction motors and transformers.

The "Scott" or T-transformer connection which he devised in 1894 for transformation from two-phase to three-phase or vice versa, has borne his name. From observations during the testing of insulators, he predicted corona loss between high-tension wires which he measured in laboratory tests in 1895, inaugurating the investigations in this field by others. He made various contributions to the early knowledge of inductive interference and to its mitigation. At the International Electrical Congress in St. Louis in 1904, he was Chairman of the Power Transmission Section.

He has contributed a large number of papers to the publications of the engineering societies and other technical periodicals. He founded the Westinghouse Club and inaugurated the *Electric Journal* for the training of young engineers.

Professor Scott, now an Honorary Member of the American Institute of Electrical Engineers, has been a member since 1892, and was President during the year 1902-03. He had previously served as Manager 1895-98 and Vice-President 1899-1901. He has served on many Institute committees, and is at present a member of the Lamme Medal, and Student Branches Committees, and representative on the Commission of Washington Award and American Engineering Council.

His advocacy of the erection of a building for headquarters of the national engineering societies led to the receipt of the gift from Mr. Carnegie which made possible the culmination of his ideas in the Engineering Societies Building, and he was Chairman of the Building Committee representing the Engineering Societies and the Engineers' Club. He was a member of the Conference Committee of the national societies of Civil, Mechanical, Mining, and Electrical Engineers which formulated plans for the Federated American Engineering Societies, now American Engineering Council, and has served this organization continuously as an Institute representative.

During his presidency of the Institute, he gave vigorous support to Secretary Pope's suggestion that local meetings of the Institute be developed. His paper "Proposed Developments of the Institute," presented in September 1902, contained several recommendations, one of which led to the establishing of Student Branches in engineering schools.

As President of the Society for the Promotion of Engineering Education (1921-23), Professor Scott proposed a serious consideration of methods of improving the teaching of engineering. His efforts led the Society to undertake an investigation of what it could do "to develop, broaden and enrich engineering education." He has served as Chairman of the Board of Investigation and Coordination in this notable undertaking in which there has been active cooperation of engineering schools, engineering societies and industry, and which has instituted the Summer School for engineering teachers.

In addition to his memberships and offices mentioned above, Professor Scott is a member of the American Society of Mechanical Engineers, National Electrical Light Association, Illuminating Engineering Society, American Philosophical Society, and Engineers' Society of Western Pennsylvania (Past-President). He has received the following honorary degrees: M. A., Yale University; Sc. D., University of Pittsburgh; and Eng. D., Stevens Institute of Technology.

## Close of World Engineering Congress Tokyo, Japan

The closing sessions of the World Engineering Congress and the Tokyo Sectional Meeting of the World Power Conference were held in Parliament House, Tokyo, Thursday, November 7th.

Twenty-six countries were represented. About 500 delegates and guests from foreign countries were in attendance, about one-half of whom were from the United States; the total attendance exceeded one thousand. About 800 papers were presented at the sessions of the Engineering Congress and approximately 150 at the Power Conference. A large proportion of the 240 Japanese members of the A. I. E. E. were in attendance with the addition of about 30 foreign members.

The Japanese engineers were untiring in their efforts to make the visit of the foreign engineers and guests both profitable from a professional standpoint and enjoyable socially. The general sentiment of the visitors was expressed in a resolution unanimously adopted at the final session of the Congress, Nov. 7th, highly commending the officers, committees, and others concerned, for the effective manner in which the Congress had been planned and conducted, both professionally and socially.

The Transactions of the Congress will be published in book form but will not be available for several months; in the meantime pamphlet copies of all the papers that could be printed in advance will be on file in the Engineering Societies Library, New York. Correspondence regarding the availability of separate copies of the Congress papers may be addressed to Mr. Maurice Holland, Secretary of the American Committee, 33 West 39th Street, New York; similarly, inquiries regarding the Power Conference papers may be addressed to O. C. Merrill, Chairman, American National Committee of the Conference, 917 15th Street, N. W., Washington, D. C.

At the final session of the Congress the following resolutions were adopted upon the recommendation of the Resolutions Committee:

**RESOLUTION NO. 1**

BE IT RESOLVED that the Delegates of the Various Nations be requested to explore the situation, with a view to ascertaining the opinion, in their own Countries, as to the advisability and practicability of bringing forward for action some plan aiming at WORLD ENGINEERING FEDERATION:

AND that this subject should have a place allotted to it at the ne WORLD ENGINEERING CONGRESS.

**RESOLUTION NO. 2**

WHEREAS it is understood that the Netherlands Royal Institute of Engineers is willing to take the lead in the investigation of certain irrigation questions of international importance.

BE IT RESOLVED that this congress favors an international investigation, to be carried on under the auspices of said Institute, Division Netherlands East India, for report to the next World Engineering Congress on the following questions:

FIRST. What subsidies, direct or indirect, are paid by various governments to secure the construction of large irrigation and flood control and drainage works and with what justification?

**RESOLUTION NO. 3**

BE IT RESOLVED that the attention of Engineering Society in the various countries participating in this Congress be directed to the importance of a full understanding of hydrostatic uplift, internal stresses and other factors affecting the safety of dams, and that the American Society of Civil Engineers be requested to invite the cooperation of the committee on Dams of the International Navigation Congress, also the World Power Conference and the Engineering Organizations of the other countries represented at this Congress, in a study of this problem.

The daily press of Japan, both Japanese and English, devoted an unusually large amount of space to the Congress day by day, many of the papers being printed each day in full or in abstract.

In its leading editorial on Nov. 8th, the Japan *Advertiser* said in part:

The reader who has skimmed the daily summaries of the proceedings of the World Engineering Congress and the sectional meeting of the World Power Conference must have asked himself if there is anything in the material life of man which does not come within the vast net of the modern engineer. * * * * The discussions on scientific management and rationalization showed how engineers are being aroused to the social consequences of the progress of their science. The exchange of views on this subject by engineers from old countries where labor is superabundant and where its too rapid displacement by machines may be the greater of two evils, and new countries where labor is relatively scarce was a feature of the conference.

One of the acts of the Congress was the appointment of a preparatory committee to consider the formation of a world federation of engineers. Such an organization would develop professional spirit and in this way would form and clarify professional opinion on those large questions. But the engineers, true to their engrossing tasks, were chiefly engaged in the pooling of knowledge—the expression par excellence of the professional spirit—and the merest glance through the daily reports shows what a rich and varied field they cultivated. The great experiment of holding this gathering in Japan has been fully justified.

## Doctor Shibusawa Elected an Honorary Member

At a special meeting of the Institute held November 7th in Parliament House, Tokyo, Japan, Doctor Motoji Shibusawa, Dean of Engineering at Tokyo Imperial University, was installed as an Honorary Member of the American Institute of Electrical Engineers.

The meeting, which was attended by a large number of members of the Institute of Electrical Engineers of Japan and of the American Institute, was presided over by Past-President Frank B. Jewett of New York, who stated that the Constitution of the Institute provides that honorary membership may be conferred upon those who have rendered acknowledged eminent service to electrical engineering, and only upon the unanimous vote of all the members of the governing body. There are at present only eleven men, including Doctor Shibusawa, who have been thus honored. The election of this distinguished Japanese engineer occurred on August 6, 1929 in New York and this special meeting for the purpose of publicly announcing the matter had been arranged because of the presence in Tokyo of a large number of American electrical engineers in attendance at the World Engineering Congress.

Past-President R. F. Schuchardt, outlined the achievements of Doctor Shibusawa and presented the Certificate of Honorary Membership to him. Doctor Shibusawa was born in Saitama Prefecture, Japan, on October 25, 1876. He received his technical education at the Imperial University of Tokyo, being graduated from the Department of Electrical Engineering in 1900. He continued his studies in Europe and America.

He was appointed an Electrical Engineer of the Electrotechnical Laboratory of the Department of Communications in 1906, and in 1909 was appointed to the additional post of Engineer of the Imperial Railway Board.

In 1919 he was appointed Engineer-in-Chief, Bureau of Electricity, Ministry of Communications and in 1919 he also took the additional post of Professor of the Tokyo Imperial University, to which latter post he was definitely transferred in 1924.

He was appointed Dean of the Faculty of Engineering, Tokyo Imperial University, in 1929, and received the degree of "Kogakuhakushi" (Doctor of Engineering) in 1911.

He was elected President of the Institute of Electrical Engineering of Japan in 1924, and has held the post of President of the Japanese Electrotechnical Committee since 1921. He has been a member of the American Institute of Electrical Engineers since 1905.

Doctor Shibusawa has contributed largely to the technical literature of Japan.

Others on the platform were President Yamamoto, of the Institute of Electrical Engineers of Japan, Past-Presidents D. C. Jackson and P. M. Lincoln, National Secretary, F. L. Hutchinson, and Elmer A. Sperry, Charter Member of the American Institute.

Doctor Shibusawa responded with an address in which he expressed high appreciation of the great honor that had been conferred upon him.

## Annual $10,000 Prize Award for Achievement in Science

As announced by O. B. Capen, President of the Popular Science Publishing Company, the largest single monetary award in America for scientific accomplishment has been created by *Popular Science Monthly* in an annual prize of $10,000, accompanied by a gold medal, to the American citizen who, during the preceding year, has achieved scientific work of greatest potential value to the world.

The award was instituted with the dual purpose of heightening the interest of the American people in laboratory and workshop benefit to a community, and of focusing attention upon the many scientific workers who, without thought of personal profit, toil to better man's control of his physical surroundings.

The first award will be made September 1930, and the initial period of scientific accomplishment to be considered by the Committee of Award will be the twelve months ending June 30, 1930. All scientific workers, professional or amateur, academic or commercial, are eligible. Serving on the Committee of Award are Charles G. Abbot, Secretary of Smithsonian Institution; Collins P. Bliss, Director of Popular Science Institute; Samuel A. Brown, Dean of New York University and Bellevue Hospital Medical College; George K. Burgess, Director of the United States Bureau of Standards; William W. Campbell, President of the University of California; Harvey N. Davis, President of Stevens Institute of Technology; Arthur L. Day, Director of the Geophysical Laboratory, Carnegie Institution; E. E. Free, Consulting Engineer; Travis Hoke, Editor of *Popular Science Monthly;* Frank B. Jewett, Vice-President of the American Telephone and Telegraph Company; Vernon Kellogg, Permanent Secretary, National Research Council; Charles F. Kettering, President of General Motors Research Corporation; Arthur D. Little, President of Arthur D. Little, Inc.; John C. Merriam, President, Carnegie Institution; Robert A. Millikan, Chairman, Executive Council, California Institute of Technology Henry Fairfield Osborn, President, American Museum of Natural History; Elmer A. Sperry, Chairman of the Board of Directors, Sperry Gyroscope Co.; Samuel W. Stratton, President of Massachusetts Institute of Technology; Elihu Thomson, Director, Thomson Laboratory of the General Electric Co., Lynn, Mass.; Edward R. Weidlein, Director, Mellon Institute of Industrial Research; Henry Herman Westinghouse, Chairman of the Board of Directors, Westinghouse Airbrake Co.; Albert E. White, Director of the Department of Engineering Research, University of Michigan; Willis R. Whitney, Director of Research, General Electric Co., Schenectady, N. Y., and Orville Wright.

# STANDARDS

### Specifications for Vacuum Tube Bases

The tentative American Standard "Specifications for Vacuum-Tube Bases" is now available in printed form. It is a single sheet and can be obtained at ten cents per copy from the Institute of Radio Engineers, 33 West 39th Street, New York, N. Y.

### Recommended Practise on Methods of Indicating Bolt Heads, Nuts and Screw Threads

A report is now in circulation on Proposed American Recommended Practise on Line Work dealing particularly with "Methods of Indicating Bolt Heads, Nuts and Screw Threads." This report is the result of the work of a subcommittee of a Sectional Committee working under the Rules of Procedure of the American Standards Association and joint sponsorship of the American Society of Mechanical Engineers and the Society for the Promotion of Engineering Education. The committee solicits criticisms and suggestions from those interested in drafting room practise. Copies of the report may be obtained from the chairman of the subcommittee, S. Ketcham, 140 Cedar St., New York, N. Y. to whom all communications should also be sent.

### Proposed Federal Specifications for Watchmen's Report and Time Recording Apparatus

The Federal Specifications Board of the United States Government has issued a proposed Federal Specification for Watchmen's Report and Time Recording Apparatus. These specifications are for installations in large office buildings or groups of smaller buildings with watchmen's supervisor continuously on duty. They are in the formative stage and are being submitted to representative manufacturers for comment. Any one interested in this project should write directly to Doctor George K. Burgess, chairman, Federal Specifications Board, Washington, D. C.

### Report on Method of Indicating Dimensions on Drawings

Subcommittee No. 2 of the Sectional Committee for Drawings and Drafting Room Practise has submitted a report on "Method of Indicating Dimensions." This proposal contains sections on (1) Indicating Dimension Lines and Figures, (2) Expressing Feet and Inches, (3) Finish Marks, (4) Dimensioning Holes, (5) Diameters, etc. (6) Dimensioning and Limits. Criticisms and comments of the report are solicited. Copies may be obtained by addressing E. B. Neil, A. S. M. E. Headquarters, 33 West 39th St., New York, N. Y.

### American Standards Association Joins I. S. A.

At the December 18, 1929 meeting of the American Standards Association announcement was made that A. S. A. had become a member body of the International Standards Association. In addition to the United States, the following countries are members of I. S. A.: Austria, Belgium, Czechoslovakia, Denmark, Finland, France, Germany, Holland, Hungary, Italy, Japan, Norway, Poland, Roumania, Russia, Sweden, Switzerland.

# AMERICAN ENGINEERING COUNCIL

### A. E. C. ANNUAL MEETING IN JANUARY

The Annual Meeting of American Engineering Council will be held in Washington, January 9, 10, and 11, at the Mayflower Hotel. It is expected that 75 delegates representing 24 engineering societies having a constituent membership of over 57,000 engineers will be present.

The meeting of the Assembly, which is the legislative and policy-forming body of American Engineering Council, will be preceded by meetings of the Executive Committee and Administrative Board.

The following delegates representing the various organizations as listed will attend the meeting as members of the Assembly for the first time:

Professor Harold B. Smith, A. I. E. E.; Baxter L. Brown, L. L. Calvert, J. F. Coleman, H. S. Crocker, A. J. Dyer, C. E. Grunsky, Frank Gunby, A. J. Hammond, J. C. Hoyt, Dean Anson Marston, C. H. Paul, G. T. Seabury, Francis Lee Stuart, Frank M. Williams, A. S. C. E.; Thos. D. Campbell, W. B. Ferguson, Dean Chas. E. Ferris, Prof. W. H. Kenerson, John H. Lawrence, Chas. Piez, Dean A. A. Potter, A. S. M. E.; C. L. Harrod, Indiana Engineering Society; W. W. Horner, Engineers Club of St. Louis.

### UNIFORM REGISTRATION LAW FOR ENGINEERS

Following the passage at the annual meeting of the National Council of State Boards of Engineering Examiners of a resolution suggesting such a conference, Anson Marston, President of the American Society of Civil Engineers, called a conference which met December 7, 1929, in New York City, to consider the possi-

bility and desirability of a standard uniform registration law for engineers.

The meeting was presided over by A. J. Saville of the A. S. C. E.; in attendance were: J. O. G. Gibbons, A. S. M. E.; J. H. Griffin, A. A. E.; C. S. Hammatt, National Council of State Boards of Engineering Examiners; H. A. Kidder, A. I. E. E.; T. K. Legare, Secretary, National Council of State Boards of Engineering Examiners; J. T. Powers, A. R. E. A.; C. J. Ullrich, A. A. E.; Gardner S. Williams, A. E. C.

Major Gardner S. Williams, representing the American Engineering Council, stated that in view of the fact that Council had taken no definite position on the subject of registration, and that since the question was largely a state problem, he attended the meeting only in a spirit of helpful cooperation and was not in a position to commit American Engineering Council to any particular uniform law. As evidence of the fact that Council was well informed on the subject, he called attention to a recent analysis of registration laws of the various states of the U. S. made by Council, in which 58 different items were analyzed and recorded about each of the 27 state registration laws.

## Great Lakes District Holds Fine Meeting in Chicago

A meeting of outstanding interest was held under the auspices of the Great Lakes District of the Institute at the Drake Hotel in Chicago on December 2, 3, and 4. Six hundred members and guests were in attendance at the technical and social functions.

Four well attended technical sessions were held; a report of these is given later in this announcement.

Two sessions for Students were on the program and the interest which these held was manifested by the attendance of 150 students. A complete report of these sessions is given in the Student Activities department of this Journal.

Many took advantage of the inspection trips which were arranged. Among the places visited were Crawford Avenue Station of the Commonwealth Edison Company and State Line Generating Station, the stage of the Chicago Civic Opera with its new equipment for lighting control, a dial-operated exchange of the Illinois Bell Telephone Company, the Hawthorne Plant of the Western Electric Company, and a plant of the Illinois Steel Company.

A dinner dance which was enjoyed by all was held on the evening of December 3.

### REPORT ON TECHNICAL SESSIONS

In the following paragraphs is a brief résumé of the technical sessions. The papers for the respective sessions are listed and the outstanding points of the discussion resulting given. Complete discussion on each paper will be published in the Transactions together with the paper itself.

#### Session on Communication

*Recent Developments in Telephone Toll Service*, W. H. Harrison, American Telephone & Telegraph Co.

*The Chicago Long Distance Toll Board*, E. O. Neubauer and G. A. Rutgers, Illinois Bell Telephone Co.

*Manufacture of Telephone Carrier and Repeater Apparatus*, R. C. Glasier, Western Electric Co.

*Air-Transport Communication*, E. L. Jones and F. M. Ryan, Bell Telephone Laboratories.

In the discussion following the presentation of these papers, H. A. Harris explained that the planning of toll line construction necessitates careful considerations of loads 15 to 20 years in advance. W. W. Walters drew attention to the superiority of equipment which is now available for toll circuits.

R. L. Hartman pointed out that the efficient use and operation of toll circuits is as important as proper design, installation and maintenance. W. M. Jamison called attention to the need for hundreds of tests which are made daily on the Chicago long distance toll board in order to make sure that the circuits remain in good condition. H. S. Osborne described the general toll switching plan which covers this country and embraces 2700 toll centers.

M. M. Fells mentioned that his company, the National Air Transport, has had considerable trouble with radio reception on aeroplanes due to the deposition of ice on the antennas. Even when the antenna is enclosed in an insulating tube the formation of ice on the tube causes signals to decrease greatly in intensity.

#### Session on Power Plants

*The Future of Higher Steam Pressures*, I. E. Moultrop, Edison Electric Illuminating Company of Boston.

*Use and Design of Fault Ground Bus*, R. M. Stanley and F. C. Hornibrook, Byllesby Engg. and Mgt. Corp.

*Increased Voltages for Synchronous Machines.* C. M. Laffoon, Westinghouse Elec. & Mfg. Co.

*Double Windings for Turbine Alternators*, P. L. Alger, E. H. Freiburghouse and D. D. Chase, General Electric Co.

*A 40,000-Kw. Variable-Ratio Frequency-Converter Installation*, E. S. Bundy, Niagara, Lockport and Ontario Power Co., and A. Van Niekirk and W. H. Rodgers, Westinghouse Elec. &. Mfg. Company.

A. W. Rauth warned that in a station such as Brunot Island Switch House, extreme care should be taken to avoid connecting together electrically the insulated sections of the building. This he pointed out would cause faulty relay operation. H. R. Summerhayes suggested that the differential-relay system of protection is preferable to the fault ground bus for stations having a small number of large-capacity circuits. In a station having a large number of feeders on each bus, he stated, the fault ground bus is simpler, cheaper and more reliable. D. D. Higgins stated that two years' experiences in Chicago have proved that the fault ground bus is very satisfactory.

R. W. Wieseman stated that he has found mica insulation very satisfactory for high-voltage generators. P. L. Alger disagreed with Mr. Laffoon's recommendations for high-potential tests on the generator windings. He stated that he believed that the best measure of insulation strength is the life at four times normal voltage at 100 deg. cent. He recommended a test with slightly reduced voltage applied for five minutes. Both Mr. Alger and S. L. Henderson declared that the real advantage to be gained from high-voltage generators will come from connecting them directly to transmission lines. Both pointed out that now this is not possible nor will it be feasible until methods of protecting against surges are better developed.

In commenting on the paper dealing with double-winding generators, C. M. Laffoon stated that in his opinion, the most desirable types of double windings for commercial purposes are the split phase and the alternate pole types. P. W. Robinson called attention to the advantages of the Scherbius type of control for a frequency changer set.

#### Session on Transmission and Distribution

*Theory of a New Valve Type Lightning Arrester*, J. Slepian, R. Tanberg and C. E. Krause, Westinghouse Elec. and Mfg. Company.

*Low-Voltage A-c. Networks*, R. M. Stanley and C. T. Sinclair, Byllesby Engg. and Mgt. Corp.

*An Economic Study of an Electrical Distributing Station*, W. G. Kelley, Commonwealth Edison Co.

*Experience with Carrier-Current Communication on a High-Tension Interconnected Transmission System*, Philip Sporn and R. H. Wolford, American Gas & Electric Co.

*Automatic Regulation for Synchronous Condensers Equipped with Superexcitation*, L. W. Thompson and P. J. Walton, General Electric Co.

Several discussers emphasized the reliability with which the a-c. network protector has functioned in actual operation. They also spoke of the advantages which the network plan offers in the expansion of a growing system. Henry Richter warned that

feeder regulators cannot be omitted in many cases although they are not used in the system described in the paper. In answer to a question, Mr. Sinclair stated that the carbon-pile starter for motors connected to the network has been very satisfactory. He stated that the problem of voltage fluctuation on his system is not serious.

Edward Beck stated that over 2500 arresters using the principle explained in the Slepian, Tanberg, and Krause paper have been giving satisfactory operating service.

In commenting upon the paper by Messrs. Sporn and Wolford, R. J. Wensley stated that the double-frequency high-power system of communication has given entirely satisfactory service to the Alabama Power Company and the Indiana Electric Company. Mr. Sporn agreed that this system is satisfactory in itself but that where the number of carrier-current channels is limited, twice as many single-frequency circuits may be used.

Session on Research and Development

*Polyphase Induction Motors*, W. J. Branson, Robbins & Myers, Inc.

*Recording Torque Indicator*, G. R. Anderson, Fairbanks, Morse & Co.

*Effect of Armature Resistance on Stability of Synchronous Machines*, C. A. Nickle and C. A. Pierce, General Electric Co.

*Ionization Currents and the Breakdown of Insulation*, J. J. Torok and F. D. Fielder, Westinghouse Elec. & Mfg. Co.

*Heat Radiation in Inter-Reflection Cases*, A. D. Moore, University of Michigan.

Several discussers spoke on the great value of the paper by Dr. Branson referring to the accuracy of the method and particularly to the great amount of time which its use will save.

J. T. Tykociner in connection with the paper by Messrs. Torok and Fielder, stated that the cathode ray oscillograph has given some very valuable data on the breakdown of gases but that further data, such as space distribution of current and potential, are desirable. He suggested that the tools of physicists and astrophysicists, particularly the spectroscope, might well be employed to obtain further information.

## A. I. E. E. Directors Meeting

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at the Drake Hotel, Chicago, Ill., on Tuesday, December 3, 1929, during the Great Lakes District Meeting.

There were present: President Harold B. Smith, Worcester, Mass.; Vice-Presidents Herbert S. Evans, Boulder, Colo.; B. D. Hull, Dallas, Tex.; H. A. Kidder, New York, N. Y.; W. S. Rodman, Charlottesville, Va.; W. T. Ryan, Minneapolis, Minn.; E. C. Stone, Pittsburgh, Pa.; Directors J. E. Kearns, Chicago, Ill.; A. M. MacCutcheon, Cleveland, Ohio; E. B. Meyer, Newark, N. J.; C. E. Stephens, New York, N. Y.; Assistant National Secretary H. H. Henline, New York, N. Y.

The minutes of the Directors meeting of October 18, 1929, were approved.

Announcement was made of the death, on November 1, of Honorary Secretary Ralph W. Pope and of Past-President John W. Lieb, and the following memorial resolutions were adopted:

Whereas, the death of Ralph Wainwright Pope, on November 1, 1929, has removed from the American Institute of Electrical Engineers a leading pioneer who served faithfully and unceasingly as its Secretary for more than twenty-six years and has been Honorary Secretary since his retirement from active duty in 1911;

Whereas, during his active service the Institute grew from the humblest beginning to a large and effective organization; he was constantly watchful for opportunities to advance the welfare of the membership, the engineering profession, and the general good of humanity; and his genial, sympathetic spirit as well as his high ideals won the gratitude and appreciation of Directors, members, and a multitude of friends;

Whereas, his enthusiastic and indefatigable interest was one of the strong contributing factors in the development of Sections and Branches which have done much to bring the advantages offered by the Institute to members and Students in many widely separated localities, be it

Resolved Therefore: That in behalf of the membership, the Board of Directors hereby expresses its profound sorrow at the death of one of the Institute's most faithful members and extends to the members of the family of Mr. Pope its deepest sympathy in their bereavement; and be it

Resolved: That these resolutions be inscribed in the minutes and a copy be transmitted to the members of his family.

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Whereas, the death on November 1, 1929, of John William Lieb, Senior Vice-President of the New York Edison Company, removed from the profession of electrical engineering one of its most highly esteemed representatives, and from the Institute a member who during much of the time since his admission in 1887 served it effectively in numerous capacities, including those of Manager, Vice-President, and President;

Whereas, he was a pioneer in the fields of electric public utilities and technical education, and his sound judgment, vigorous leadership, high executive ability, and devotion to duty won him high respect as a man and as an engineer, be it

Resolved: That the Board of Directors in behalf of the membership of the American Institute of Electrical Engineers expresses its sense of the great loss which the engineering profession has sustained in his death; and be it further

Resolved: That these resolutions be entered in full in the minutes and that a copy be transmitted to members of his family.

The death, on November 7, of Guido Semenza, Local Honorary Secretary of the Institute for Italy, was reported; and the following minute was adopted:

The Board of Directors of the American Institute of Electrical Engineers, having learned with profound sorrow of the death of Guido Semenza, Local Honorary Secretary for Italy, on November 7, 1929, desires to incorporate in the minutes a tribute to his memory.

Mr. Semenza was an electrical engineer with great intellectual ability and charming personality, known and respected internationally. He had ability to combine to an unusual degree scientific studies and industrial developments. Through his sound judgment and progressive ideas he made many notable contributions to the art of power transmission and distribution, and became a valued director of many companies, as well as an active member of numerous scientific and technical societies. It is, therefore, with keen appreciation of the great loss sustained by both the profession and the Institute that sincere sympathy is hereby extended to his family and associates.

A report of a meeting of the Board of Examiners held November 13, 1929, was presented and the actions taken at that meeting were approved. Upon the recommendation of the Board of Examiners, the following actions were taken: 835 Students were enrolled; 111 applicants were elected to the grade of Associate; five applicants were elected to the grade of Member; 29 applicants were transferred to the grade of Member; six applicants were transferred to the grade of Fellow.

The Board ratified approval by the Finance Committee for payment, of monthly bills amounting to $23,919.51.

Upon the recommendation of the Committee on Student Branches, authorization was given for the organization of Student Branches at Pratt Institute, Brooklyn, N. Y., and Texas Technological College, Lubbock, Tex.

Mr. C. E. Skinner was nominated, for election by the United Engineering Society, as a representative of the Institute on the Engineering Foundation Board for the three-year term beginning in February 1930.

Report was made of the discharge by the United Engineering Society of the Committee on War Memorial to American Engineers, which committee handled the details of the donation by American engineering societies of a clock and carillon to the University of Louvain. The Board voted that an expression of appreciation of its work be transmitted to the committee.

Other matters were discussed, reference to which may be found in this and future issues of the Journal.

## The Engineering in President Hoover's Message

The message on the general state of the union, prepared by our second engineer President, has been sent to Congress. Out of more than 12,000 words contained in this message of great interest to all engineers as citizens, it contained over 3000 words dealing specifically with engineering projects,—among them waterways, flood control, public buildings, highways, air mail, commercial aviation, railways, merchant marine, electric power regulation, Radio Commission, Muscle Shoals, Boulder Dam, conservation, and governmental reorganization.

Among the President's recommendations dealing with these subjects are the following:

*Federal Power Commission:* "I recommend that authority be given for the appointment of full time commissioners, the authority of the commission to be extended to certain phases of power regulation." *Radio Commission:* "The reorganization of the Radio Commission into a permanent body." *Muscle Shoals:* "It is most desirable that this question be disposed of.... such parts of these plants as would be useful, and the revenues from the remainder should be dedicated for all time to the farmers of the United States for investigation and experimentation on a commercial scale in agricultural chemistry.... I do not favor the operation by the government of either power or manufacturing business except as an unavoidable product of some other major public purpose." *Boulder Dam:* "The Secretary of the Interior is making satisfactory progress in negotiation of the very complex contracts required for the sale of the power to be generatd at this project. These contracts must assure the return of all Government outlays upon the project. I recommend that the necessary funds be appropriated for the initiation of this work as soon as contracts are in the hands of Congress." *Conservation:* "I recommend that Congress authorize a moderate sum to defray the expense of a Commission on Conservation of Public Domain." *Government Reorganization:* "This subject has been under consideration for over 20 years. It seems to me that the essential principles of reorganization are two in number: First, all administrative activities of the same major purpose should be placed in groups under single-headed responsibility; second, all executive and administrative functions should be separated from boards and commission and placed under individual responsibility, while quasi-legislative and quasi-judicial and broadly advisory functions should be removed from individual authority and assigned to boards and commissions. Indeed, these are the fundamental principles upon which the Government was founded, and they are the principles which have been adhered to in the whole development of our business structure, and they are the distillation of the common sense of generations.

## Washington Society of Engineers Hold Annual Banquet

The Washington Society of Engineers held its annual banquet in the Raleigh Hotel, Washington, D. C., December 11. The dinner was presided over by Vice-President F. A. Hunnewell, with approximately 250 engineers in attendance, and appreciative attention was given addresses which were delivered by Congressman L. W. Douglas, representative at large from Arizona, and L. W. Wallace, Executive Secretary of American Engineering Council.

Congressman Douglas, an engineer, gave an interesting and clear presentation of the subject of Interstate Electric Rate Regulation. After showing the complexity of the problem and the many difficulties encountered with various possible solutions, he proposed the plan of permitting the states themselves to regulate such matters, under the authority granted by the constitution of the United States which permits states to formulate treaties between themselves.

L. W. Wallace based his address upon a paper "Engineers in American Life," prepared by him and Mr. J. E. Hannum of New York, and published in the December number of *Mechanical Engineering*.

"Of the 28,805 'notable living men and women of the United States' named in 'Who's Who in America' (1928-29), men of science comprise 30.4 per cent; lawyers, 15.2 per cent; and physicians and surgeons, 7.3 per cent. Among 2858 engineers and architects there are, or have been, 10 governors, 13 members of Congress, two members of the Cabinet, and the President of the United States. The findings of this assay clearly show that engineers and architects are versatile, internationally minded; and leaders, not followers."

## The Institute and the Engineer[1]

By Carroll O. Bickelhaupt

This year the American Institute of Electrical Engineers is forty-five years old. At the turn of the century it had a membership of less than twelve hundred; in 1929 it has a membership of over eighteen thousand, and during the last fiscal year, more than twelve hundred new members qualified.

Why do engineers join the Institute? What does the Institute do for its members? How does it attract and retain its membership? What do members gain through their affiliation with this organization? These are pertinent questions, although the size of membership and its continued growth are *prima facie* evidence of its value to the individual engineer.

The objects of the Institute are well known. It is organized "*for the advancement of the theory and practise of electrical engineering and the allied arts and sciences, the maintenance of a high professional standing among its members, and the development of the individual engineer.*" The engineering profession, however, has a wider and more fundamental responsibility, which, while not formally stated in the enumeration of the purposes of the Institute is nevertheless generally recognized and accepted by the membership. This is the obligation of the engineer for civic service.

The engineer has played an important and in many respects a leading part in the advancement of civilization and the spread of culture. He has made the world a safer, cleaner, and healthier place in which to live. His contributions in making life easier and happier are incalculable and constitute important and inspiring chapters in world progress. He has created for his profession a place in our social structure which carries with it definite responsibilities and obligations that cannot be denied or avoided. No statement, therefore, of the aims and purposes of the American Institute of Electrical Engineers would be complete which did not recognize that which is so much a part of the creed of the engineer and of his profession,—this fundamental responsibility to serve.

With the vast complexity of our modern life, we are living in an epoch in which science and the development of the allied arts are being served through organized group effort rather than by the labor of individual genius. While genius has penetrated and may yet further penetrate the wilderness beyond the borders of knowledge, the development of this hinterland and its adaptation to human purposes and requirements is accomplished in our day largely by the systematic work of organized groups. Here is one great reason for the banding together of the profession in a great organization builded upon foundations of common purpose.

In joining the Institute, the engineer seeks affiliation with those who are pursuing similar lines of thought and endeavor so that his work may count for the greatest progress. He joins the Institute because he seeks to serve and because he realizes that his individual service will be integrated with that of others through channels which the Institute provides. His membership affords him an opportunity for expression and for discussion with

1. Presented at a meeting of the Birmingham Section A. I. E. E. Nov. 21, 1929.

his fellows, and provides a means for exchange of ideas and knowledge and for professional development.

During the last fiscal year the 54 Sections of the Institute held 460 meetings, with a total attendance of 73,254; the one hundred Branches held 940 meetings, with a total attendance of 47,408. In addition, there were three national conventions during the year and regional meetings were held in three Districts. At these meetings, papers of interest and importance to the profession were presented and discussed. If it be estimated that if at each of the more than 1400 meetings held during the year, an average of only two papers were presented and discussed, some idea can be had of the importance and scope of this activity of the Institute.

These papers are carefully scrutinized and digested by committees, and those of immediate value and importance are made available for the use of the membership through publication in the monthly JOURNAL, and those of more permanent value are recorded in the Quarterly TRANSACTIONS. These publications constitute a current index of developments in the electrical arts and provide a record of progress nowhere else available. Their value to the profession cannot be measured, and the Institute renders one of its greatest services in collecting, publishing, and disseminating this vast fund of electrical knowledge.

It is difficult to estimate the educational value of the Institute's professional meetings and discussions, particularly to the younger engineers. The research required to secure the data and to draw the conclusions necessary to the preparation of a paper or a discussion cannot help but contribute to the development of the individual; and writing the paper in itself has a definite educational value.

Many engineers have difficulty in expressing their ideas either in writing or in talking before others. This is a difficulty which may definitely limit the effectiveness of the individual and may prevent him from doing the work of which he is otherwise capable.

The day Lord Kitchener sailed for Russia on the British cruiser *Hampshire*, which was sunk by a German mine off the Orkneys, he lunched at Scapa with Admiral Viscount Jellicoe. In talking about his work at the War Office, Lord Kitchener referred to the difficulty he experienced in dealing with questions discussed in the Cabinet, "a difficulty," which Admiral Jellicoe notes, in relating this last conversation with Lord Kitchener, is "felt by most soldiers and sailors, whose training does not fit them to state or argue a case and who frequently find difficulty in doing so. They are, as a rule, accustomed to carry out their ideas without first having to bring conviction to the minds of men who, although possessing great general knowledge and administrative experience, have naturally but little acquaintance with naval and military affairs, which in themselves form a life time study."

Had Admiral Jellicoe been talking about engineers instead of soldiers and sailors, his statement would have had equal force. Too often engineers find themselves in similar difficulties and to an extent which constitutes a real handicap to themselves and to their work. In providing a vehicle and an incentive for expression through the preparation and presentation of written papers, and through informal discussions from the floor of its meetings, the Institute affords a potent means which any member may take to improve his own ability to express himself in writing and in public presentation and discussion.

Through its affiliation with American Engineering Council, on the Assembly of which the Institute has proportionate representation with other leading engineering societies, the membership is afforded an opportunity for participating in crystallizing the thought and policy of the engineering profession as a whole with respect to matters of public welfare in which the profession is interested. American Engineering Council, the first President of which now occupies the White House, is an organization "*to further the public welfare wherever technical knowledge and engineering experience are involved, and to consider and act upon matters of common concern to the engineering and allied technical professions.*"

The work of the Institute in connection with electrical standards is of great value to the profession. This work is carried on within the Institute by a general standing committee. In connection with this work, the Institute is associated with the American Engineering Standards Committee organized in 1918 to serve as a national clearing house for engineering and industrial standardization and to provide an information service on standardization matters. It has been stated that if the Institute performed no other service beyond its work in connection with electrical standardization matters, its existence would be justified. This, however, is but one of its many important services.

Through technical committees, of which there are at present eighteen, each dealing with an important electrical subject, the Institute studies the problems of the profession and reports to its membership, acts as a clearing house for specialized technical knowledge and data, and contributes to the coordination of effort looking to advances and developments in the electrical arts.

In addition to its activities in association with American Engineering Council and American Engineering Standards Committee, the Institute is also represented on the Council of the American Association for the Advancement of Science, the National Research Council, National Safety Council, International Electrotechnical Commission, and many other organized groups which are contributing to human progress along lines in which the work of the engineer is of great and important service.

With the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Society of Civil Engineers, and the United Engineering Society, the Institute maintains in the Engineering Societies' Building in New York, a free public reference library which contains over 125,000 volumes. Among the interesting items in this library is the Latimer-Clark collection presented to the Institute by Schuyler Skaats Wheeler and containing every publication in the English language on the subject of electricity published prior to 1886. It includes many rare and valuable volumes published in the sixteenth and seventeenth centuries. In connection with this library, the Library Service Bureau maintains a staff of experts organized to abstract, translate, prepare bibliographies, search for patent purposes, carry on statistical investigations, and do other research work at nominal cost.

Of importance to members generally is the employment service which the Institute has conducted for a long time in conjunction with similar services of the other great engineering societies. This service consists principally in acting as a medium in bringing together employers and engineers seeking employment. The "Employment Service Bulletin," published monthly in the Institute JOURNAL, has served to place many engineers in positions of responsibility throughout the world.

For members traveling in foreign countries, the Institute has made reciprocal arrangements with a number of European electrical engineering societies which entitle its members while abroad to membership privileges in foreign societies for a period of three months. Institute members desiring to avail themselves of these exchange privileges may secure credentials through the Institute's National Secretary.

No statement of the Institute's activities would be complete without reference to the great work it is carrying on among students in the technical colleges. This work is organized through Student Branches, of which at present there are more than one hundred. These Branches constitute a forum in which the student of electrical engineering may discuss technical matters with fellow students and with members of the other groups of the Institute. Through participation in the activities

of the Branches, students become acquainted with the work and methods of the Institute and gain experience which puts them in a position to meet their obligations to the profession, and to further advance themselves in their chosen work. They meet the membership of the Institute, become acquainted with the problems of the profession and secure an insight into professional life which is of direct value not only to themselves but to the profession for which they are preparing themselves.

During the last fiscal year, district conferences on student activities were held in seven of the ten Geographical Districts. Also two conferences involving smaller groups of Branches were held. These conferences were attended by the student officers of the Branches and by the Counselors, who are delegated from the electrical engineering faculties of the colleges. In addition, seven student conventions were held along lines similar to the regional and national meetings of the Institute. At these conventions, technical papers of real merit were presented by students and discussed generally.

No one who has been in touch with the student activities of the Institute can doubt the tremendous value of this work in helping the young engineer to get into his stride and to enter his chosen field under the most advantageous conditions. This work not only insures the perpetuation of the ideals and ideas of the Institute and the profession which it represents, but is a source of real assistance and inspiration to those who are fitting themselves for service through the electrical arts.

These are among the more important contributions of the Institute to the profession. In a limited way, their enumeration indicates the scope of the service which the Institute is performing, and may serve to indicate why engineers join the Institute.

Just what, however, can the Section do for its members? The answer to this question seems clear. Through its affiliation with the national organization, it can bring to its members all of the advantages which membership in the Institute carries with it. It provides a means for professional and personal contact between engineers who live in the same city or neighborhood. Through Section meetings, problems of special local interest may be discussed as well as more general technical matters.

Many of the most interesting technical discussions of the Institute are carried on in Section meetings where there can be more general participation by those present and where, from the nature of things, discussion can be had on a less formal basis than is necessarily required in the larger regional and national meetings. Interest may be stimulated and contact with developments in other parts of the country maintained by inviting prominent speakers from outside the Section. Experience has indicated, however, that maximum benefit is derived if the majority of papers are prepared by members of the local Section. The Section plays an important part also in the student activities of the Institute, and joint meetings with nearby Student Branches have commonly been found to be of inspiration and help not only to the students but to the Section members participating. In short, the Section is the active principle of the Institute and the engineer gains from his affiliation with the Section in direct proportion as he contributes to its activities.

It is unnecessary to state that the work of the Institute is conducted on the highest plane of professional ethics and dignity. The Institute recognizes no special privilege, and its work is far removed from any implication or taint of commercialism. It takes no part in partisan politics and conducts no political propaganda. It stands, and has always stood for the highest type of service, for the development of the individual engineer and for the advancement of the profession. Based upon a long record of technical accomplishment, professional integrity and ungrudging service, its character is so well established and so well known that it fills an important place in representing the electrical profession not only in national, but in world affairs.

## PERSONAL MENTION

Clyde R. Keith, formerly of the Recording Department of the Metro-Goldwyn-Mayer Eastern Studios, New York City, is now in the Recording Department of the Western Electric Co., Ltd., Inveresk House, Aldroych, London, Eng.

H. S. Evans has been transferred from Albany, New York, where he was Manager of the Albany Branch of the Vacuum Oil Company, to Denver, Colo., where he will function as Manager of the Industrial Department of the company's Denver Division, covering the States of Wyoming, Colorado and New Mexico.

E. O. Shreve, Manager of the Industrial Department of the Schenectady General Electric Company, has been appointed Assistant Vice-President on the staff of Vice-President J. G. Barry. William W. Miller, Assistant Manager of the Industrial Department, has been appointed Manager of that department to succeed Mr. Shreve.

E. B. Nichols, a well-known worker in the professional field, has been appointed Chief Engineer of the Brown Instrument Company of Philadelphia, Pa. He comes to his new position from the Technical Staff of the Bell Telephone Laboratories, Inc., and will act in an administrative capacity, supervising the Engineering Staff, a work for which his broad executive experience and ability to handle men and materials particularly fits him.

Hugh M. Beugler, for many years engaged in public utility work of a diversified nature over many portions of the United States, has now become associated with the E. Y. Sayer Engineering Corporation, of Baltimore, in connection with various project engineering and construction undertakings. The service includes preliminary surveys, development of plans, construction supervision of public utility and industrial power, and gas production projects.

Irving Langmuir, noted research worker, Associate Director of the Research Laboratory of the General Electric Company, and President of the American Chemical Society, was awarded the Chandler Medal for 1929 for his achievement in chemical science. The award was made at a national gathering of scientists at Hayermeyer Hall, Columbia University, December 27, Dr. Langmuir delivering the annual Chandler lecture on the subject "Electrochemical Intersections of Tungsten, Thorium Caecium and Oxygen." The medal was established in 1910 by friends of the late Professor Charles Frederick Chandler, pioneer of industrial chemistry.

## Obituary

**John Lee Curtis,** Electrical Engineer, Schenectady, New York, died December 2, at Clifton Springs, New York, after an extended illness. Mr. Curtis became an Associate of the Institute in 1906. He was born at Fishkill-on-Hudson March 13, 1879 and was graduated from the Riverview Military Academy, Poughkeepsie in 1897. He also attended Massachusetts Institute of Technology, from which he was graduated with a degree of S. B. in Electrical Engineering in 1902. Entering the Testing Department of the General Electric Company October 1902, he remained there until 1905, when he left the Testing Department, first going into the Drafting Room and later working on experimental telephone research. Ultimately he joined the company's Foreign Department at Schenectady, as Commercial Engineer, where he remained until he was taken ill.

**Wallace Wheaton Briggs,** who has been Vice-President and General Manager of the Grays Harbor Railway and Light Company, Aberdeen, Washington, since 1925, and was a prominent figure in the field of public utility in the West, died in Aberdeen December 9. Although a native of Newark, New Jersey, Mr. Briggs received his high school education in San Francisco,

California. In 1886, when only sixteen years of age, he entered the employ of the California Electric Light Company, remaining with it until 1891, when he joined the Electric Improvement Company of San Francisco. In 1893 he left California and for two years was with the Ft. Wayne Electric Corporation's Sales Department in Salmon, Idaho. Returning, however, to San Francisco, he became Local District Manager for the Westinghouse Electric & Manufacturing Company, and later General Manager of the Great Western Power Company of California. In 1918 he came East again to join the Westinghouse New York organization and subsequently identified himself with the Federal Light & Traction Company which controls the Gray Harbor Company, by which he was sent to Aberdeen to assume the executive duties of Vice-President and General Manager. At the time of his death he was also a member of the Executive Committee of the Northwest Electric Light and Power Association. He joined the Institute in 1906.

**Harry Wallace Jeannin,** Vice-President of the Jeannin Electric Company of Toledo, Ohio, and a Member of the Institute since 1926, died at his home in Toledo on November 19, 1929.

He was born May 31, 1869 at Cape Girardeau, Mo. After grade school he turned his talents to engineering, doing intensive reading and private experimental work in all electrical branches. In 1890 he was Manager of the Booneville, Mo. Power Station, followed by managerial positions at the power stations at Paragould and Jonesboro, Ark. In 1896 he became plant manager of the Telephone Plant at Pine Bluff, Ark.

In 1899 he joined the Wagner Electric Co. in whose employ he remained for seven years, part of this time being spent in the Engineering Department and later as Superintendent. In 1906 he became Manager of the Lewis Blind Stitch Machine Company, and in 1907, started the manufacture of the Jeannin Automobile.

In 1908 he became Chief Engineer of the Century Elec. Co., St. Louis, Mo., with which he remained seven years. From 1915 for three years he was Engineer at the Peerless Elec. Co., Warren O.; then with the National Electric Welding Co., Warren, O. This was followed by a period of consulting engineering work until he joined the American Magneto Co. in Toledo, O. In 1919 he organized the Jeannin Electric Co., Toledo, O. He has taken out quite a large number of patents relating to motors, particularly of the repulsion induction type.

**Maurice A. Oudin,** Vice-President of the International General Electric Company and a member of the Institute since 1894, died December 4 at Schenectady, in the sixty-third year of his age.

He was born in New York on March 31, 1866 and was educated in the New York public schools and the College of the City of New York, from which he was graduated with an A. B. degree in 1885. From the first he showed an interest in electrical research, doing postgraduate work in this department at Princeton, where, in 1891, he received degrees of Electrical Engineer and Master of Science.

Including the field of science, Mr. Oudin's interests were centered in Italy and the Far East. He was President of the Board of Trustees of the Italy-America Society, and was decorated last year with the Order of Commander of the Crown of Italy. He was Chairman of the Committee of the Italy-America Society and of the International Electrical Commission which represented America at the exercises commemorating the centenary of Volta's death, held at Como, Italy, in 1927. He was also decorated by the Emperor of Japan with the Order of the Rising Sun in 1911. He was a member of the Japan Society, the American Asiatic Association, the American Manufacturers' Export Association, the National Foreign Trade Council, the Electrical Manufacturers' Club, the American Institute of Electrical Engineers and the China Society. His clubs included the India House, Bankers, Century, University of New York, Mohawk Golf and Racquet of Washington.

## Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, together with the addresses as they now appear on the Institute records. Any member knowing the present address of any of these members is requested to communicate with the Secretary at 33 West 39th St., New York.

All members are urged to notify Institute Headquarters promptly of any changes in mailing or business address, thus relieving the member of needless annoyance and assuring the prompt delivery of Institute mail, through the accuracy of our mailing records and the elimination of unnecessary expense for postage and clerical work.

C. A. Baer, 1330 Pine St., Philadelphia, Pa.
J. B. Bakker, 440 Hyde St., San Francisco, Calif.
C. W. Bell, P. O. Box 424, Port Chester, N. Y.
W. T. Birdsall, 6 Vincent Place, Montclair, N. J.
C. W. Bohner, 1989 Bedford Ave., Brooklyn, N. Y.
M. A. Borislavsky, 240 E. 104th St., Apt. 5, Brooklyn, N. Y.
Garry E. Brown, 1280 Dean St., Brooklyn, N. Y.
Lung C. Chin, 200 Claremont Ave., Apt. 57, New York, N. Y.
Marcel A. Collinot, F. W. V. Rm. 1050, 11 W. 42nd St., New York.
A. A. Cory, 61 Watsessing Ave., Bloomfield, N. J.
James W. Cryder, 5516 Willows Ave., Philadelphia, Pa.
H. H. DeCamp, 414 Ella St., Wilkinsburgh, Pa.
F. S. Degener, 1015 Casgrain Ave., Detroit, Mich.
F. C. De Lay, West Texas Utilities Co., Abilene, Tex.
H. W. De Salis, Box 66, Fort Frances, Ont., Can.
F. C. Dixon, 100 Elm Ave., Mount Vernon, N. Y.
H. M. Evjen, Calif. Inst. of Tech., Pasadena, Calif.
Ernest Fick, A. T. & T. Co., 412 S. Market St., Chicago, Ill.
R. P. Fortin, Elec. & Gas Inspection Ser., 125 Prince William St., St. John, N. B.,Can.
Shah G. Ghous, P. O. Box 733, Schenectady, N. Y.
Chas. Gorrissen, Hermannstrasse 38, Hamburg, Germany.
Richard R. Grenfell, 442 6th St., Brooklyn, N. Y.
G. R. Hamrick, Sweetwater, Tex.
Henry W. Harbison, R. F. D. 1, Merriam, Kans.
John E. Hardey, Nat'l. Electrical & Engg. Co., Ltd., Box 1055, Wellington, N. Z.
C. D. Hayward, Calif. Inst. of Tech., Pasadena, Calif.
J. O. Howell, 405 South Union, Galion, Ohio.
C. Brown Hyatt, Camac and Medary Sts., Philadelphia, Pa.
Edgar A. James, 912 S. Poplar St., Allentown, Pa.
E. H. Kirkland, 6701 Cregier Ave., Chicago, Ill.
F. A. Klein, 1215 Locust St., Philadelphia, Pa.
R. F. Matthews, 123 Livingston St., Brooklym, N. Y.
D. J. McDougall, 1501 W. Pierce St., Phoenix, Ariz.
S. K. Mitra, c/o R. F. Coggeshall, Int'l Gen. Elec. Co., Schenectady, N. Y.
Douglas, Montgomery, c/o Mrs. E. Armour, 170 S. Marengo Ave., Pasadena, Calif.
F. D. Nims, 70 State St., Boston, Mass.
C. Noome, Catharijnesingel 33, Utrecht, Holland.
R. A. Patrick, 425 Granite St., Reno, Nev.
H. L. Perkins, 129 Marshall St., Petersburg, Va.
W. M. Philp, 433 Morrison St., Niagara Falls, Ont., Can.
Richard T. Quaas, 545 W. 156th St., New York, N. Y.
H. D. Rivers, 298 Central Ave., Lynbrook, L. I., N. Y.

## Talking Movie on William Stanley and the Transformer

At a meeting of the William Stanley Club of Pittsfield, Mass., December 11, at which Gerard Swope spoke, an interesting feature was the showing of a talking movie on "William Stanley and the Transformer."

The picture opened with G. Faccioli, Associate Manager, sitting in his car at the Berkshire Hills Country Club and telling the

story of his association with William Stanley and then he introduces S. W. Ashe who says a few words about Michael Faraday and the relation of his experiments to Stanley's work.

The scene is here changed to a laboratory where Mr. Ashe continues with a group of interesting experiments in electromagnetic induction and their application to the transformer. The picture concludes with E. A. Wagner, Manager of the Pittsfield Works, telling a brief story of the developments of the transformer and the results of Stanley's work.

This picture is particularly interesting as it shows what can be done by means of experiments to illustrate the fundamental laws and to show the practical applications.

The film was made by John Klenke of Schenectady and can be used on any standard talking movie outfit.

# A. I. E. E. Section Activities

### NEW YORK SECTION ILLUMINATION AND TRANSPORTATION GROUPS TO MEET THIS MONTH

Illumination Group

On Tuesday, January 7th, 1930, the first meeting of the Illumination Group of the New York Section will be held at 7.30 p. m. in Room 2 on the Fifth Floor of the Engineering Societies Bldg., 33 West 39th St., New York, N. Y. The speaker for the evening will be O. P. Anderson of the Commercial Engineering Section, Edison Lamp Works, Harrison, N. J. Mr. Anderson will take as his subject "The Heart of the Lighting System—The Incandescent Lamp." An extremely interesting speaker, with a background of 20 years in the lamp business, Mr. Anderson will give those attending a talk outlined to bring them up to date in the rapidly changing art of lighting. He will have a stage full of ingenious apparatus designed to show the fundamental features of lamps and their proper operation in a clear, yet thoroughly accurate manner.

The New York Section of the Illuminating Engineering Society have courteously extended an invitation to members to participate in their meeting to be held Thursday, January 9, 1930 at 8 p. m. in the Grand Ballroom of the Hotel St. George, Brooklyn, N. Y. This will be a private showing of the newly installed decorative lighting effects requiring over 7000 lamps. Here, for the first time, light in ever changing color constitutes the sole means of decoration. Admission will be by ticket only. Apply to J. E. Buckley, Secretary, I. E. S., N. Y. Edison Co., Room 907-S, 4 Irving Pl., N. Y. City.

Transportation Group

The second meeting of the Transportation Group will be held on the evening of Monday, January 13, 1930 at 7.30 p. m. in Room 2, Engineering Societies Bldg., 33 West 39th St., New York, N. Y. There will be two speakers with subjects as follows: "New Switching Locomotives for New York Central," by F. W. Butt, Assistant Engineer, New York Central. He will describe the combination oil-electric battery-trolley type of locomotive. The second speaker, L. G. Coleman, Manager, Locomotive Dept., Ingersoll-Rand Co. will talk on "Progress in Oil Engine Design and Application." Recent developments will be discussed by Westinghouse engineers. As is the custom in all Group meetings there will be discussion open to all and adjournment by 9.30 p. m.

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### FUTURE SECTION MEETINGS

**Akron**

January 10, 1930. *The Problem of Public Transportation in Akron*, by L. G. Tighe, Assistant General Manager, Northern Ohio Power and Light Company.

February—(exact date to be announced later). *Delayed Speech Transmission*, by Sergius P. Grace, Vice-President, Bell Telephone Laboratories.

**Cleveland**

January 16, 1930. *Electricity and the Universe*, by David Dietz, Scientist and Author.

February 20, 1930. *Recent Lightning Research*, by Dr. J Slepian, Research Engineer, Westinghouse Elec. & Mfg. Company.

**Detroit-Ann Arbor**

January 21, 1930. Ladies' Night. *Motoring Through Europe*, by Professor A. H. Lovell, Electrical Engineering Dept., University of Michigan, Ann Arbor.

February 18, 1930. *Telephone Toll Service in Michigan*, by R. Foulkrod, Plant Extension Engineer, Michigan Bell Telephone Company, Detroit, Michigan. Meeting to be held at the Michigan Bell Telephone Auditorium.

**Lynn**

January 29, 1930. *The Mysteries of Science*, by Harry C. White.

**Niagara Frontier**

January 18, 1930. *The Quest of the Unknown*, by Professor Harold B. Smith, President of the A. I. E. E. Hotel Statler, Buffalo.

February 14, 1930. *Problems in Lightning Protection on Distribution and Transmission Systems*, by H. M. Towne, Lightning Arrester Engineering Dept., General Electric Co., Pittsfield, Mass. Meeting at Power House No. 2, Edward Dean Adams Plant, Niagara Falls, N. Y.

**Pittsburgh**

January 17, 1930. *The Quest of the Unknown*, by Professor Harold B. Smith, President of the A. I. E. E. Dinner meeting, English Room, Fort Pitt Hotel.

February 11, 1930. *Lightning Arrester Developments* by E. W. Beck. *Field Investigations of Lightning Phenomena*, by J. H. Cox. (Both of the Westinghouse Elec. & Mfg. Company.)

**Toledo**

January 15, 1930. Joint meeting of all technical societies and Toledo Formans Club at the Commerce Club. Dinner. The Goodyear Rubber Company will have a representative to speak on Dirigible type of Aircraft.

February 14, 1930. *Deion Circuit Breaker*, by H. M. Wilcox, Westinghouse Elec. & Mfg. Company.

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### FIGURES ON NEED FOR INCREASED LIGHT PLACED BEFORE NEW YORK SECTION MEMBERS

At the regular monthly meeting of the New York Section of the Institute held at the Westinghouse Lighting Institute, Grand Central Palace, New York, N. Y., on the evening of December 18, 1929, an informal committee of engineers of the Section rendered a report which stated that the people of the United States can use to advantage more than five times as much light as they are using at present.

That the amount of electric light being used today is only 17 per cent of the minimum recommended level, and but 13 per cent of the probable level of greatest economic advantage, were the conclusions of the report on "How Much Light?", the first ever prepared on the subject, submitted to the meeting by Frank W. Smith, chairman of the Lamp Committee of the Na-

tional Electric Light Association, Arthur E. Allen, Vice-President Westinghouse Lamp Co., and E. E. Free, consulting engineer. These figures apply only to the indoor lighting of homes, factories, offices, etc., and take no account of the lighting of streets, highways, etc.

The report analyzed the light needs of the human eye from the standpoints of perceiving objects; doing special work, such as type setting; doing regular productive work in factories; comparisons with daylight, for which the eye was created; and computations from the characteristics of the light perceiving elements in the retina of the eye.

With data secured in these ways as a basis, the amount of light needed for each human occupation was determined; then the needs for the average family, and finally for all the families in the country.

It was estimated that the present consumption of electricity for lighting purposes was 20 billion kilowatt-hours a year, but to secure the probable illumination level of greatest economic advantage, the consumption at present would be approximately 151 billion kilowatt-hours annually.

"Our present lighting is far too dim to suit the known characacteristics of the human eye," stated the authors of the report. "If the general illumination level is brought up to that recommended by the data which have been compiled, there will be gains in comfort, in lessened eye-strain, in economic efficiency, and in the attractiveness of our homes, offices, etc. A noticeable step in the right direction will be a very considerable decrease in glare and all of its undesirable features, because glare is due in most cases to an effort to overcome by a high local illumination a too low level of illumination of one's surroundings. By correcting the general level of illumination, glare will tend to disappear, just as draughts disappear in a properly heated and ventilated building."

Following the meeting the Westinghouse Lighting Institute was thrown open to the inspection of the 500 members and guests attending.

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## POWER GROUP HEARS TALKS ON "SYSTEM CONNECTIONS"

Another very successful meeting of the New York Section Power Group was held on the evening of Monday, December 9, 1929 at 7:30 p. m. Room 2 in the Engineering Societies Bldg., where the meeting was held, was filled to its capacity with the 250 members attending. There were three speakers, each treating a different phase of the general subject "System Connections." A. E. Powers of the Westinghouse Elec. & Mfg. Co., gave a general conception of stability, both static and transient. He demonstrated his points very effectively with an ingenious mechanical model. The second speaker, I. H. Summers of the General Electric Co., gave a talk on the more commonly employed schemes of system connection—the ring bus, the synchronizing bus, double windings, and "synchronized at the load." The last speaker, T. Maxwell of the United Elec. Lt. & Pr. Co., gave a résumé of experience with the "synchronized-at the-load" connection as employed in New York City. A general discussion followed.

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## PAST SECTION MEETINGS

### Baltimore

*Electrification of the Pennsylvania Railroad*, by J. V. B. Duer, Electrical Engineer, Pennsylvania Railroad. Discussion followed. Joint meeting with A. S. M. E. and Engineers' Club. Dinner preceded meeting. November 15. Attendance 300.

### Birmingham

*What Can the American Institute of Electrical Engineers and Particularly the Birmingham Section Do for its Members*, by C. O. Bickelhaupt, Past Vice-President of the A. I. E. E., Vice-President of the Southern Bell Tel. & Tel. Co. Luncheon preceded meeting. November 21. Attendance 26.

### Boston

*Electrical Design—15 Mile Fall Development*, by E. W. Dillard, New England Power Association. Illustrated. Discussion followed. November 5. Attendance 250.

Executive Board meeting. Committee appointments announced Discussion of future Section meetings. November 5.

### Chicago

*The Quest of the Unknown*, by Professor Harold B. Smith, President A. I. E. E. Illustrated. Joint meeting with the Western Society of Engineers. Dinner preceded meeting. December 2. Attendance 240.

### Cincinnati

Joint meeting with the Engineers' Club in honor of Light's Golden Jubilee. C. J. Campbell, Westinghouse Lamp Works, gave a brief analysis of the lighting industry from its inception to the present time. Demonstrations followed. October 17. Attendance 75.

Oliver C. Schlemmer, Ohio Bell Telephone Co., gave a talk on the important features of the panel type dial telephone system which has been adopted by the Cincinnati & Suburban Bell Telephone Co. for its central office exchanges. Illustrated. November 13. Attendance 91.

### Cleveland

In the absence of Charles M. Ripley, General Electric Co., W. S. Culver delivered the address, *Illustrated Review of Social and Economic Results of Power and Machinery*, from notes written by Mr. Ripley. Illustrated. November 21. Attendance 54.

### Columbus

*Magnetic Materials*, by T. D. Yensen, Research Dept., Westinghouse Elec. & Mfg. Co. Illustrated. December 6. Attendance 35.

### Connecticut

*Flood Lighting of Large Areas*, by Crawford P. McGinnis, Pyle National Company. Professor W. H. Bristol, President, Bristol Co., presented pictures of apparatus developed for sound synchronized moving pictures. Demonstrations followed. November 19. Attendance 35.

### Dallas

New officers introduced. Talk by Vice-President B. D. Hull, on the Aims of the A. I. E. E. *The Trinity Levee Project*, by E. L. Myers, Consulting Engineer. Discussion followed. September 17. Attendance 55.

Dance and bridge. November 2. Attendance 126.

*Transatlantic Radio Telephony*, by J. C. Schelleng, Bell Telephone Laboratories, Inc. Illustrated. Members of the I. R. E. invited to attend. November 22. Attendance 152.

### Denver

*Some Experiences with the Southern California Edison Company in Connection with the Problems of Transmission Line Stability*, by W. C. DuVall, Professor of Electrical Engineering, University of Colorado. Illustrations and discussion followed. Dinner preceded meeting. November 15. Attendance 32.

### Detroit-Ann Arbor

*Power System Planning*, by L. W. W. Morrow, Editor, *Electrical World*. Dinner meeting accompanied by music and entertainment. November 12. Attendance 250.

### Erie

Annual Banquet and Ladies' Night. *What Are You Afraid Of?*, by Charles M. Newcomb. Members of Erie Technical Federation invited. November 19. Attendance 150.

### Fort Wayne

*The Quest of the Unknown*, by Professor Harold B. Smith, President of the Institute. Illustrated. Professor Smith also spoke on Institute activities. November 25. Attendance 115.

### Ithaca

*Dial Telephones*, by E. H. Goldsmith, Engineer, New York Telephone Co. Illustrated. November 22. Attendance 150.

### Kansas City

*Transatlantic Telephony*, by J. C. Schelleng, Bell Telephone Laboratories, Inc. *Recent Developments and Trend in Turbine Construction*, by H. W. Cross, General Electric Co. Illustrated. Joint meeting with A. S. M. E. and Student Branches of the University of Kansas and Kansas State Agricultural College. Refreshments. November 20. Attendance 300.

**Lehigh Valley**

Inspection trip to the Holland Generating Station of the N. J. Power & Light Co., preceded by luncheon. *The General Features of Design of the Plant and Mechanical Problems Which Had to be Solved*, by James A. Powell, Designing Engineer, W. S. Barstow & Co. *Electrical Features of the Plant*, by C. R. Kemp, Electrical Engineer of the same company. Talks by Major Horn and H. G. Harvey. September 28. Attendance 268.

*The Personnel Administration of Coal Mining*, by H. S. Gilbertson, Lehigh Coal & Navigation Co., Lansford, Pa. *Transmission Line Insulation*, by R. E. Argersinger, Chief Engineer, Stone & Webster Engg. Corp., Boston, Mass. Illustrated. Joint meeting with the Engineers' Society of North Eastern Penn. October 18. Attendance 184.

*Wonders of Sound Transmission*, by Sergius P. Grace, Assistant Vice-President, Bell Telephone Laboratories, Inc. Joint meeting with the A. I. E. E. Student Branch and the Engineers' Club. November 15. Attendance 813.

**Los Angeles**

*Recent Developments in Wax Recording*, by H. A. Frederick, Bell Telephone Laboratories, Inc. Illustrated. Dinner preceded meeting. November 19. Attendance 110.

**Louisville**

*Continuous Refrigeration Process*, by Clarence Vogt, Girdler Corporation. P. Hollenbach of the Frozen Pure Ice Cream Co. explained the apparatus in his plant, which was followed by an inspection of the same. Joint meeting with A. S. M. E. November 12. Attendance 65.

**Madison**

*The Quest of the Unknown*, by Professor Harold B. Smith, President A. I. E. E. Illustrated. Meeting preceded by dinner. November 29. Attendance 66.

**Milwaukee**

*The Quest of the Unknown*, by Professor Harold B. Smith, President of the Institute. Illustrated. Professor Smith also discussed Institute activities. November 26. Attendance 175.

**Minnesota**

*The Quest of the Unknown*, by Professor Harold B. Smith, President, A. I. E. E. Illustrated. November 27. Attendance 145.

**Oklahoma City**

Get-Together and Smoker. Adoption of By-Laws. Committee appointments announced. Vice-President B. D. Hull spoke on the activities of the Section. Film—"Transformers." November 6. Attendance 37.

*Transatlantic Radio Telephony*, by John C. Schelleng, Bell Telephone Laboratories, Inc. November 21. Attendance 195.

**Philadelphia**

*Turbine Electric Drive for Merchant Vessels of Major Importance*, by Frank V. Smith, General Electric Co., Schenectady, N. Y. Illustrated. November 18. Attendance 100.

*Electrical Engineering of Sound Pictures*, by Dr. F. L. Hunt, Sound Picture Laboratory, Bell Telephone Laboratories, Inc. Illustrated. December 9. Attendance 450.

**Pittsburgh**

*What's Coming in Aviation*, by W. B. Stout, Stout Metal Airplane Co., Division of Ford Motor Co., Detroit, Michigan. Joint meeting with the Engineers' Society of Western Pennsylvania and Pittsburgh Aero Club. November 19. Attendance 365.

**Pittsfield**

*Across Asia's Snows and Deserts*, by J. Clarke, Assistant Director, American Museum of Natural History. Illustrated. Informal dinner preceded meeting. November 5. Attendance 873.

*Super-Speeded Speech*, by John B. Taylor, Consulting Engineer, General Electric Co. Members of the Springfield Section and Engineering Society of Western Massachusetts present. Dinner preceded meeting. November 19. Attendance 650.

*How the Underworld Affects our Lives*, by Jack Black. Previous to the meeting Mr. Black was entertained at dinner. December 3. Attendance 621.

**Portland**

*Some Public Utility Merchandising Problems*, by V. H. Moon, Pacific Power & Light Co.; *Kilowatt-hour Sales*, by J. C. Plankington, Northwestern Electric Co. Illustrated. Buffet lunch followed the meeting. November 26. Attendance 84.

**Providence**

*Automatic Switching*, by Thomas A. Barry, General Electric Co. J. W. Young, Narragansett Electric Co., and E. S. Esty, Blackstone Valley Gas & Elec.Co., outlined briefly the various automatic substations of their respective companies. Inspection trip and dinner followed. November 12. Attendance 60.

**Rochester**

*Ultra High Frequency Transmission and Reception*, by A. Hoyt Taylor, Naval Research Laboratory;

*Television with Cathode Ray Tube for Receiver*, by V. Zworykin, Westinghouse Elec. & Mfg. Co. Joint meeting with the I. R. E. November 18. Attendance 235.

*Modern Safety Methods in Spillway Dam Design*, by Carl C. Cooman, Rochester Gas & Elec. Co. This lecture preceded an inspection trip to the hydraulic laboratory of the Rochester Gas & Elec. Co. to witness a demonstration of tests on the model of a dam. Joint meeting with the Rochester Engineering Society and local Section American Society of Civil Engineers. December 6. Attendance 79.

**St. Louis**

*Transatlantic Radio Communication*, by J. C. Schelleng, Bell Telephone Laboratories, Inc. Illustrated. Resolution passed to send letter of condolence to the family of the late Walter H. Millan. November 19. Attendance 73.

**San Francisco**

All-day excursion to the Benicia Arsenal as guests of the War Department, with other San Francisco technical societies. Luncheon furnished by the Benicia Chamber of Commerce. Address by Major General David P. Barrows, ex-President of the University of California. September 19. Attendance 155.

*Russia as Seen by a Western Engineer*, by Joseph S. Thompson, President, Pacific Electric Manufacturing Co.;

*Contemporary European Engineering*, by L. E. Reukema, Associate Professor of Electrical Engineering, University of California. Dinner preceded meeting. October 25. Attendance 145.

*Chain Broadcasting*, by Donald I. Cone, Transmission & Protection Engineer, The Pacific Tel. & Tel. Co., and Don E. Gilman, Vice-President, National Broadcasting Co. Dinner preceded meeting. November 21. Attendance 74.

**Schenectady**

*Super-Speeded Speech*, by J. B. Taylor, General Electric Co. Illustrated. November 15. Attendance 250.

**Seattle**

*Applications of Electricity on Farms*, by Glen Cushing, Puget Sound Power & Light Co., and *Indirect Lighting*, by Lyman D. Morgan, Pittsburgh Reflector Co. Talk by A. F. Darland on the work of the Membership Committee. November 19. Attendance 48.

**Sharon**

*The Quest of the Unknown*, by Professor Harold B. Smith, President of the Institute. Illustrated. Film, "Hydroelectric Power Production in the New South" preceded the lecture. Professor Smith entertained at dinner before the meeting. October 31. Attendance 134.

**Springfield**

Announcements regarding National and District prizes. John Newton spoke briefly on the objects of the A. I. E. E. and urged those present to secure new members. Address by F. C. Barton, Radio Engineering Dept., General Electric Co., on sound pictures, illustrated with films and slides. November 12. Attendance 114.

**Toledo**

*Applications of Electricity to the Manufacture of Brass*, by C. F. Anderson, American Brass Co. Film, "Mine to Consumer" presented. November 15. Attendance 50.

Meeting conducted by Messrs. Green, Webb, and Gildersleeve of the Standard Underground Cable Co. Mr. Gildersleeve described the Type H cable, and temperature tests made underground. Discussion followed. November 23. Attendance 36.

**Toronto**

Professor R. W. Angus spoke on his recent trip to Europe, giving interesting accounts of European developments in the field of hydraulic engineering. Illustrated. Joint meeting with the Engineering Institute of Canada, Toronto Branch, and Ontario Section of the A. S. M. E. November 7. Attendance 250.

W. J. Moulton-Redwood gave an address on New Zealand, its geography, scenery, the habits and customs of its native inhabitants, all being illustrated with slides loaned through the courtesy of the New Zealand Government. November 22. Attendance 58.

**Utah**

*New Source of Ultra-Violet Rays*, by Edward A. Evans, Westinghouse Lamp Co. Two-reel film—"Hydroelectric Power Production in the New South." November 11. Attendance 21.

**Washington**

*Modern Control for Traffic Signals*, by K. W. Mackall, Crouse-Hinds Co. Dinner preceded meeting. November 12. Attendance 111.

**Worcester**

*Future Possibilities of Lighter-Than-Air Craft*, by B. R. Jacobs, Goodyear Tire & Rubber Co. November 20. Attendance 200.

# A. I. E. E. Student Activities

## STUDENT ACTIVITIES AT CHICAGO DISTRICT MEETING

### Monday Morning Session

The first session of the District Meeting held in Chicago, December 2-4, 1929, was devoted to a discussion of Branch activities. Professor W. T. Ryan, Vice-President, Great Lakes District No. 5, called the meeting to order and presided during the transaction of a few items of business.

Professor L. S. Foltz, Counselor, Michigan State College Branch, was elected to fill the vacancy on the executive committee of the District Committee on Student Activities caused by the resignation of Professor A. N. Topping. Professor F. A. Fish, Counselor, Iowa State College Branch, was elected as the incoming member of the committee. Professor F. A. Rogers, Counselor, Lewis Institute Branch, being the senior member of the executive committee, will become chairman on August 1, 1930. H. E. Wulfing, Commonwealth Edison Company, is to continue as the practising engineer member of the executive committee.

Vice-President Ryan then turned the meeting over to Professor J. H. Kuhlmann, Counselor, University of Minnesota Branch and Chairman of the District Committee on Student Activities. Reports of the activities of their respective Branches were presented by the Chairmen of all the fifteen Branches in the District.

Previous to the opening of the program, the following judges had been appointed to award a prize of $10.00 to the Student who presented the best report: Professor W. S. Rodman, Vice-President, District No. 4, H. E. Wulfing, practising engineer member of executive committee of the District Committee on Student Activities, and H. H. Henline, Assistant National Secretary. The judges were unanimous in the decision to award the prize to E. G. Conroy, Chairman of the University of Notre Dame Branch.

Upon the request of the Chairman, H. H. Henline, Assistant National Secretary, reported beiefly upon the proposed plan for encouraging enrolled Students to become Associates immediately after the expiration of their enrolment. After a thorough discussion, the Committee on Student Activities approved the general plan proposed.

### Tuesday Afternoon Session

The efforts of the Committee on Student Activities to secure student papers for presentation at the District meeting resulted in the receipt of thirteen papers which were presented at the Tuesday afternoon session, at which Professor J. H. Kuhlmann presided. The complete program of this session is given below:

*Relation between the Branches and the Institute*, by H. H. Henline, Assistant National Secretary.

*Determination of the Temperature of Underground Power Cables from Load*, by J. E. Dean, Michigan State College Branch.

*Electricity on a Modern Ocean Liner*, by Clement J. McDonald, Armour Institute of Technology Branch.

*Electric Power Transmission in Iowa*, by Ellis M. Ellingson, The State University of Iowa Branch.

*Personnel Selection in a Public Utility*, by Alois Altstadt, Marquette University Branch.

*Headlight Testing*, by John C. Newhouse, University of Minnesota Branch.

*A Discussion of the Recent Public Utility Investigation at Washington*, by Edward G. Conroy, University of Notre Dame Branch.

*Mercury Arc Rectifiers*, by Willard L. Taylor, Lewis Institute Branch.

*Methods of Teaching Engineering*, by Rocco D. Perone, University of Notre Dame Branch.

*Cooperative Engineering Education*, by R. J. Abele and F. J. O'Keefe, University of Detroit Branch.

*Testing of Reduction Gear Units*, by George Mauer, Marquette University Branch.

*Recent Trends in Stage Lighting Control*, by Gordon Dahlem, Marquette University Branch.

*Experience with the Single-Phase Condenser Motor*, by Stanley Burgduff, Marquette University Branch.

*A Summer with Western Electric Company*, by Lewis H. Austin, Iowa State College Branch.

The Students showed a keen interest in their subjects and appreciated the opportunity of presenting and discussing their papers at the District Meeting.

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## MEETING IN DISTRICT NO. 4

### Technical Session

The third annual meeting in District No. 4 for the discussion of student activities and the presentation of student technical papers was held at the University of Virginia, Charlottesville, November 29 and 30, 1929. Following the registration on Friday morning and a luncheon at University Commons, the first session was held at 2 p. m. with Professsor W. J. Seeley, Chairman, District Committee on Student Activities, presiding. The following program was presented:

*Welcome for A. I. E. E.* Professor W. S. Rodman, Vice-President, Southern District (No. 4), and Counselor, University of Virginia Branch.

*Power Progress*, by J. R. Gilbert, Georgia School of Technology Branch.

*The Electrical Engineering College Graduate and Life*, by W. Farrell Barksdale, Chairman, Mississippi A. and M. College Branch.

*The Theory and Application of the High Frequency Furnace*, by David Lawrie, University of Florida Branch. (Second Prize)

*The Saluda River Project*, by Gerald H. Preacher, Chairman, University of South Carolina Branch. (First prize).

*Cooperative Method of Engineering Education as Applied at the University of Louisville*, by Hardin T. Clark, Chairman, University of Louisville Branch.

*The River Bend Steam Station*, by J. H. Nichols, North Carolina State College Branch. (Third Prize).

*The Measurement of Heat Transfer Through Insulating Materials*, by A. W. Payne, University of Florida Branch.

The first, second, and third prizes of $25.00, $15.00, and $10.00, respectively, were awarded as indicated above. The prizes were the results of joint contributions of the five Sections in District No. 4, and the W. S. Lee Engineering Corporation.

The seven papers named above were selected from eleven which had been previously submitted. The students showed an unusual amount of interest in this program, and the presentation and discussion of a number of the papers were excellent.

### Conference on Student Activities

In the evening, a dinner for Counselors and Branch Chairmen was held at the Monticello Hotel, and this was followed immediately by the annual Conference on Student Activities with Professor W. J. Seeley presiding.

The subjects named below were presented:

Report of Counselor Delegate to Swampscott, Mass., Convention—Professor W. J. Seeley, Chairman, Committee on Student Activities, District No. 4.

Selection of Branch Papers for Presentation at A. I. E. E. Conferences—Introduced by Professor T. F. Ball, Counselor, University of South Carolina Branch.

Recommended Programs for Regular Meetings of Branches—Introduced by Professor L. L. Patterson, Counselor, Mississippi A. and M. College Branch.

The Question of Freshmen and Sophomore Membership in Local Branches—Introduced by Professor S. R. Rhodes, Counselor, Clemson College Branch.

Methods of Getting Students to Write Papers—Introduced by Professor W. W. Hill, Counselor, Alabama Polytechnic Institute Branch.

Branch Attendance at Meetings to be Addressed by President Smith in February and March—Introduced by Professor W. S. Rodman, Vice-President, District No. 4.

All Branches in the District except one were represented at this conference, and the Branch Chairmen took an unusually keen interest in the discussion of the subjects presented. The Chairmen carried on a large part of the discussion.

In the discussion of Professor Ball's topic, considerable emphasis was placed upon the desirability of a thorough discussion of means of increasing the interest of Students in the Institute, and also the importance of distinguishing properly between the two types of meetings; namely, the Conference on Student Activities, and the Student Technical Session.

After a thorough discussion of freshmen and sophomore membership in Branches, the following resolution was adopted:

> We believe that it is of real benefit to the engineering student to early come into contact with the practical side of his chosen profession, and therefore, we believe that students of the Freshmen and Sophomore classes should be encouraged to attend the meetings of the local Branches of the National Engineering Societies.

In this discussion the fact was brought out that the sophomores who attended Branch meetings are usually among the most active members in their junior and senior years.

It was decided that the next Student Activities Meeting will be held in Louisville in connection with the District Meeting in November 1930, and that the Counselor of the University of Louisville Branch at that time should be Chairman of the District Committee on Student Activities.

Saturday morning was devoted to an inspection trip to Monticello, the birthplace of Thomas Jefferson who founded the University of Virginia.

## PAST BRANCH MEETINGS

### Alabama Polytechnic Institute

*Sketch of Life at ROTC Camp*, by Secretary O. T. Allen. Chairman T. S. Winter spoke on his trip to the Eta Kappa Nu Convention at the University of Illinois. November 14. Attendance 15.

D. O. Baird, Student, explained his trip to the E. C. M. A. Convention at Purdue University. November 21. Attendance 24.

Professor W. W. Hill, Counselor, and Chairman T. S. Winter explained the Student Convention at Charlottesville. December 5. Attendance 19.

### University of Arizona

*Electric Burglar Alarm*, by George Walton, Student; and

*Summer Experiences with Tucson Gas & Electric Co.*, by C. Wilcox, Student. October 4. Attendance 13.

*Magnetic Nail Picker for Highways*, by Fred Denny, Student; and

*Magnetic Alloys of Iron, Nickel, and Cobalt*, by Roy Goar, Student. October 11. Attendance 13.

*Street Railways*, by John McBride, Student; and

*Screen Grid Vacuum Tubes*, by Kenneth Kelton, Student. October 18. Attendance 13.

Film—"Story of Anaconda." October 25. Attendance 121.

### Armour Institute of Technology

*The Fundamental Unit in the Electric Utility Field*, by Alex. D. Bailey, Commonwealth Edison Co. Joint meeting with A. S. M. E. Branch. November 15. Attendance 74.

### Brooklyn Polytechnic Institute

Three-reel film—"Conowingo Hydroelectric Development." November 13. Attendance 80.

### Bucknell University

Demonstration of Tesla Coil and various gas filled tubes by Professor Irland. November 20. Attendance 49.

### California Institute of Technology

*Engineering Progress in the Last Twenty-Five Years, Especially in Southern California*, by H. H. Cox, Los Angeles Bureau of Power and Light. Luncheon preceded meeting. November 19. Attendance 34.

### University of California

*History and Present Development of Short Wave Radio Communication*, by W. G. Wagener, Research Engineer, Federal Telegraph Co.; and

*Résumé of Recent Hetch Hetchy A. I. E. E. Trip and Brief Description of the Project*, by R. W. Hollis, Jr., Student. Illustrated. Refreshments. November 20. Attendance 33.

### Carnegie Institute of Technology

*The Problems of an Industrial Control Engineer*, by R. L. Allewelt, Sales Engineer, General Electric Co. Illustrated. December 11. Attendance 36.

### Case School of Applied Science

Mr. Merrill, N. E. L. A., gave an illustrated talk on illumination in the home. Dinner preceded meeting. November 19. Attendance 32.

### University of Cincinnati

*X-Rays, X-Ray Tubes, and their Uses*, by E. B. Graves, Kelley-Keott Co., Covington, Ky. Illustrated. Refreshments served. November 20. Attendance 30.

### Clarkson College of Technology

Committee reports presented. Discussion of future activities. November 12. Attendance 19.

Inspection trip to the Aluminum Plant at Massena, N. Y., where the largest converter station in the world is located. November 19. Attendance 19.

Inspection trip to the Aluminum Plant at Massena, N. Y. November 21. Attendance 22.

### Clemson Agricultural College

*Radio Tests to Eliminate Fading*, by J. J. Butler, Student;

*How Engineers View Life*, by J. M. McPherson, Student;

*Cab Signals for Railroad Signaling*, by D. R. Bostick, Student;

*Current Events*, by C. V. Rentz, Student; and

*The Life of Thomas A. Edison*, by W. M. Estes, Student. Illustrated. John Klenke outlined the possibilities for college men in the General Electric Co. November 21. Attendance 54.

*Arc Welding in Building Construction*, by E. C. Byrd, Student;

*Reliability of 220 Kilovolt Transmission Lines*, by W. D. Craig, Student;

*World's Largest Transformer*, by H. W. Dorset, Student; and

*Report of Student Conference*, by G. W. Sackman. Student. Luncheon. December 5. Attendance 25.

**Colorado Agricultural College**

*Characteristics that make for Success*, by Dean S. Arthur Johnson. November 25. Attendance 12.

**University of Colorado**

*The Engineering Features of the Boulder Dam*, by H. F. McPhail, Electrical Engineer, U. S. Reclamation Bureau. Illustrated. Discussion followed. Film—"Driving the Longest Railroad Tunnel in the Western Hemisphere." November 20. Attendance 62.

*Experiences at Westinghouse*, by Bryan R. Burke, Student;

*Electrical Standards in Public Utility Work*, by Paul Shelton, Student. Illustrated. Inspection trip through Professor C. M. McCormick's Standardizing Laboratory. December 4. Attendance 38.

**Cooper Union**

*Some Side-Lights on Communication*, by C. F. Farnell, Curator, Bell Telephone Laboratories Museum. November 20. Attendance 47.

**Cornell University**

*Railway Signaling*, by R. M. Shumway, Student; and

*Sound Pictures*, by C. Breen, Student. Refreshments. November 15. Attendance 38.

**University of Denver**

*The Latest Developments in the Electrical Industry*, by William Hooper, Westinghouse Electric & Mfg. Co. November 13. Attendance 24.

Dr. James L. Trayon, Massachusetts Institute of Technology, spoke on the graduate courses offered at M. I. T. November 25. Attendance 45.

**University of Detroit**

*General Principles of the Street Car*, by A. C. Colby, Supt. Equipment Dept., Detroit Street Railways. Luncheon at Peter Pan Restaurant. November 7. Attendance 50.

*Relation of Biology to Engineering*, by Dr. R. A. Muttkowski, Head of Biology Dept.;

*Induction Motors in Industry*, by Norman S. Yost, Howell Electric Co., Howell, Mich.;

Film—"Modern Manufacturing with the Stable-Arc Welder." Joint meeting with the University of Detroit Engineering Society and the Society of Chemical Engineers. Refreshments. November 18. Attendance 250.

Reports on the Chicago District meeting, by Professor Harry O. Warner, Head of Electrical Engineering Department, and R. F. Abele and W. F. Haldeman, Students.

Films—"Electrical Transmission of Speech" and "Pictures by Wire." December 5. Attendance 55.

**Drexel Institute**

*Talking Motion Picture Machinery*, by Jack T. Seiler, Student; and

*Railroad Electrification*, by Edwin K. Cliver, Student. December 2. Attendance 20.

**Duke University**

Branch activities discussed. Three Students discussed papers presented at Student meeting in Charlottesville. December 10. Attendance 16.

**University of Florida**

*Short Wave Radio*, by D. C. Trafton, Student; and

*Graduation—Then What?*, by F. H. Worthington, General Electric Co. Entertainment and smokes. December 2. Attendance 28.

**Georgia School of Technology**

Film—"Wizard of Wireless." Lee B. Mann, Branch Chairman, spoke on the advantages of Student enrolment. November 5. Attendance 55.

**State University of Iowa**

Election of officers. September 25. Attendance 3.

*Hydrogen Cooling of Motors and Generators*, by P. G. Arvidson, Student;

*Internal Combustion Engines in Railroad Service*, by E. R. Arvidson, Student; and

*Muscle Shoals Project*, by D. Cozine, Student. October 2. Attendance 31.

*Railway Signal Line*, by E. C. Dunn, Student; and

*Lighting Arrangements to Stretch the Sporting Day*, by J. D. Fitzgerald, Student. October 9. Attendance 23.

*Iowa's Electric Transmission Lines and Plants*, by E. M. Ellingson, Student. October 23. Attendance 30.

Film—"Principles of Magnetism"—Part One

*Telephone Circuits*, by W. W. Elwell, Student; and

*Keokuk Power Plant*, by R. K. Hemphill, Student. October 30. Attendance 35.

Talk by Vice-President Guernsey of the American Tel. & Tel. Co. Joint meeting of all engineering societies. November 6.

Film—"Principles of Magnetism"—Part Two

*Transformer Oils*, by B. F. Gibney, Student;

*Neon Gas*, by O. B. Hathaway, Student; and

*Purpose of A. I. E. E.*, by T. F. Taylor, Branch Chairman. November 13. Attendance 30.

Film—"Principles of Electrostatics"

*Applications of Neon Gas*, by L. L. Halets, Student. November 20. Attendance 33.

*Talking Movies*, by D. Jenkins, Student. November 27. Attendance 33.

**University of Kansas**

*Transatlantic Telephony*, by J. C. Schelleng, Bell Telephone Laboratories, Inc.;

*Recent Development and Trend in Turbine Construction*, by H. R. Cross, General Electric Co., Chicago. Joint meeting with A. S. M. E. Branch. November 20. Attendance 250.

**University of Kentucky**

Professor W. E. Freeman, Counselor, spoke on the Theremin, a musical instrument played by waving the hands over two coils. Chairman W. F. Steers spoke on the aims of the Institute. November 12. Attendance 44.

**Lehigh University**

*New Materials and Devices that have Affected the Art of Communication*, by Sergius P. Grace, Assistant Vice-President, Bell Telephone Laboratories, Inc. Demonstrated. Joint meeting with Lehigh Valley Section and Engineers Club. November 15. Attendance 800.

**Lewis Institute**

John B. Holmberg, Holmberg Air Mapping Co., gave a lecture on aerial photographic surveys. Photographs exhibited. November 15. Attendance 85.

**Louisiana State University**

Election of officers. November 21. Attendance 22.

Fred H. Fenn, Chairman, spoke on his trip to the Student Convention at Charlottesville. December 2. Attendance 22.

**University of Louisville**

Messrs. Talcott and Lips, Students, spoke on *Chain Broadcasting* and *Diverter Pole Generators*, respectively. November 14.

**Marquette University**

Branch activities discussed. Mr. Gates, Graduate Student, spoke on standardization of electrical machinery at the Allis-Chalmers Mfg. Co. November 7. Attendance 56.

**Massachusetts Institute of Technology**

Inspection trip to the Lynn Works of the General Electric Co. November 12. Attendance 60.

*An Introduction to the Bell System and Its Work*, by J. H. Bigelow, New York Telephone Co. Motion pictures and slides presented. Dinner meeting. November 22. Attendance 306.

**Michigan State College**

Business meeting. November 21. Attendance 17.

**University of Michigan**

*Pioneering Railroad Electrifications*, by N. W. Storer. Talks by Professor A. D. Moore, and A. M. Dudley, Engineering Supervisor of Development, Westinghouse Elec. & Mfg. Co. November 18. Attendance 120.

*Human Problems in Corporate Industry*, by C. E. Eveleth, Vice-President General Electric Co. December 2. Attendance 100.

**School of Engineering of Milwaukee**

Meeting to celebrate Edison's Golden Jubilee and the Tenth Anniversary of the A. I. E. E. Student Branch. Dr. J. D. Ball gave an informal chat on the life and achievements of Edison. Refreshments and entertainment. October 21. Attendance 303.

**Mississippi A. & M. College**

Film—"The Single Ridge". November 21. Attendance 20.

**Montana State College**

*A Change in the Power Distribution System of Bozeman*, by E. Fitzstephens, Student;

*Handling 54 Messages an Hour on the World's Fastest Liner*, by Wm. F. Matthews, given by Norman Hovey, Student;

*The Electrification of a Large Gold Mine*, by J. F. Wiggert, given by Carl F. Hollensteiner, Student. November 14. Attendance 154.

*Recent Developments in the Talking Movies*, by C. R. Hanna, given by William McKay, Student;

*Paper Insulation on Transformer Conductors Increases Quality*, by E. G. Reed, Westinghouse Elec. & Mfg. Co., given by Paul O. Koetitz, Student;

*Diesel Electric Passenger Locomotive for the New York Central Railway*, by S. T. Dodd, given by Mr. Micka, Student. November 21. Attendance 159.

*Electric Melting Improves Cast Iron*, from *Electrical World*, given by Erwin F. Sauke, Student;

*Number Nine Thousand*, from World's Work, given by Arthur Shelden, Student; and

*An Ammeter for Motor Starting Currents*, by H. B. Smith, Westinghouse Elec. & Mfg. Co., given by Roy W. Rydell, Student. December 5. Attendance 159.

**University of Nebraska**

Three-reel film—"Arc Welding." *A Talk on a Technical Question*, by Darrell Schneider, Branch Chairman. November 20. Attendance 22.

Film, "Hydroelectric Power Production in the New South." Talk by Dr. E. B. Roberts, Educational Dept., Westinghouse Elec. & Mfg. Co. outlining the qualifications necessary for the various divisions of engineering, and the opportunities for the engineering graduate in his chosen field. Joint meeting with A. S. M. E. Branch. December 4. Attendance 84.

**Newark College of Engineering**

Joseph Allan, Bendix Aviation Corp., spoke on electrical equipment of airplanes. December 2. Attendance 27.

**College of the City of New York**

Inspection trip to the Southwark Mfg. Co., Philadelphia, Pa. and the Baldwin Locomotive Works, Chester, Pa. November 22. Attendance 52.

Inspection trip to the Holophane Co., N. Y. C. Lectures by Messrs. Tuck and Dixon on the various phases of illumination. December 4. Attendance 21.

**New York University**

Talk by Mr. Prebble, Vice-President and Chief Engineer, Mechanical Handling Systems, Detroit, on the application of all types of conveyors to manufacturing processes. Illustrated. Talk by a representative of Spencer Lens Co., Buffalo, on the Delineascope, which is a new type of projector for slides. Discussion of Branch activities. November 25. Attendance 46.

**North Carolina State College**

Banquet. *Activities of A. I. E. E.* and *Norwood Plant and other Hydroelectric Plants*, by F. M. Nash, Supt., Norwood Plant, Carolina Power & Light Co. November 19. Attendance 48.

*River Bend Steam Station*, by J. H. Nichols. This paper received third prize when presented at the Student Convention at Charlottesville. H. W. Horney, Branch Chairman gave a report of the Student Convention. Decembr 3. Attendance 34.

**University of North Carolina**

Illustrated talks by six students on the projects inspected while attending the student meeting in Charlottesville. November 21. Attendance 27.

**University of North Dakota**

Talk on *Western Electric Sound Pictures* and summer experiences at the Western Electric Co. by John S. McKechnie. November 13. Attendance 13.

*New Methods of Protecting Telephone Wires from Lightning* and *Power Arc Follow-Up*, read by Mr. Nelson of the Northwestern Bell Telephone Co. Demonstrated. November 20. Attendance 33.

Three-reel film—"Conowingo Hydro-Electric Plant." December 4. Attendance 43.

**University of Notre Dame**

*The Life of Michael I. Pupin*, by Clarence Klein, student.

*The National Broadcast Chains*, by D. A. Ransom, American Tel. & Tel. Co., Detroit. Illustrated. Joint meeting with Engineers' Club. Refreshments and smokes served. November 18. Attendance 217.

**Ohio Northern University**

*Reclaiming Rubber and Power Used*, by H. A. Leatherman, Student; and *The Use of Turbo-Electric Drive in Ships*, by P. D. Luikhart, Student. November 7. Attendance 29.

**Ohio State University**

*New Deion Circuit Breaker*, by H. L. Rawlins, Graduate Student. Discussion followed. Dinner preceded meeting. November 21. Attendance 25.

**Ohio University**

Election of officers. November 13. Attendance 16.

**Oklahoma A. & M. College**

Film—"The Single Ridge." November 14. Attendance 65.

Two films—"Hydroelectric Power Production in the New South," and "New York's Newest Subway." December 3. Attendance 45.

**University of Oklahoma**

*The Engineering of Buttons*, by Elden M. Curry, Student. Discussion of plans for future meetings. Music and entertainment. November 18. Attendance 24.

**Oregon State College**

Professor F. O. McMillan, Counselor, spoke on Student enrolment in the Institute. Ben Griffith, Branch President, related experiences at the Pacific Coast Convention. Committee appointments announced. October 9. Attendance 40.

*Electrolysis Survey of Telephone Cables in Portland*, by A. L. Albert, Instructor in Electrical Engineering. Discussion of plans for future meetings. November 11. Attendance 28.

**University of Pittsburgh**

*The Relation of Ohm's Law to Human Behavior*, by C. S. Coler, Manager, Educational Dept., Westinghouse Elec. & Mfg. Co. Film—"Movie Nite". Refreshments and music. November 7. Attendance 60.

Professor H. E. Dyche, Counselor, gave a talk for the benefit of the freshmen. November 7. Attendance 73.

*Transatlantic Communication*, by Guy McCracken, Student. Mr. Curtiss, Radio Engineer, Westinghouse Elec. & Mfg. Co. gave a short explanation of the new type radio. November 14. Attendance 69.

*On the Bottom*, by F. C. Rankin, Student. November 21. Attendance 68.

**Princeton University**

*Photoelectric Cells*, by W. R. MacNamee, Graduate Student. Discussion of the electrification of the Pennsylvania Railroad System between New York and Philadelphia. November 21. Attendance 6.

**Purdue University**

*Power Systems in Central America*, by S. Q. Hayes, Westinghouse Electric & Mfg. Co. Illustrated. November 21. Attendance 100.

*Engineering Appraisals*, by W. Y. Armstrong, American Appraisal Co. November 26. Attendance 25.

**Rhode Island State College**

Film—"Power." November 20. Attendance 125.

*Electrification of Railroads*, by Gust Verros. Discussion of plans for smoker. December 5. Attendance 18.

**Rose Polytechnic Institute**

*The Development of a Pleasing Personality*, by J. R. Gibbens, Student. Discussion followed. November 25. Attendance 29.

**Rutgers University**

*Internal Combustion Engines in Railroad Service*, by F. C. Wegel, Student; and

*High Voltage Phenomena During Thunderstorms*, by F. P. Fisher, Student. October 22. Attendance 20.

*Conveyors as an Aid in Industrial Productive Processes*, by Norman H. Preble, Vice-President and Chief Engineer, Mechanical Handling Systems, Inc. Joint meeting with the A. S. M. E. Branch and A. S. C. E. Chapter. November 5. Attendance 22.

**University of South Carolina**

*Radio Communication for Railways*, by Professor T. F. Ball, Counselor. Film—"The Cascade Tunnel." November 8. Attendance 30.

Talk on the General Electric Test Courses, by J. K. Persons, General Electric Co. November 15. Attendance 35.

Film—"Hydroelectric Developments." Discussion of student meeting at the University of Virginia. December 4. Attendance 20.

**South Dakota State School of Mines**

Discussion of plans for annual frolic. November 21. Attendance 22.

**University of South Dakota**

*Abolishing Traffic Intersections without Grade Separation*, by Carl Bauman, Student. October 7. Attendance 7.

Film—"Modern Manufacturing with a 'Stable Arc' Welder." October 31.

*The Golden Jubilee of Light*, by Myron Cole. November 4. Attendance 9.

**University of Southern California**

I. L. Bateman, Graduate Student, spoke on his experiences while connected with the Bell Telephone Laboratories, Inc. November 13. Attendance 33.

*Telephone Interference*, by Ted Blakesley, Graduate Student. November 20. Attendance 38.

**Southern Methodist University**

Business meeting. November 20. Attendance 18.

Plans for future meetings discussed. November 26. Attendance 13.

*Transmission over Cable*, by H. P. Lawther, Transmission Dept., Southwestern Bell Telephone Co. December 4. Attendance 14.

**Stanford University**

Illustrated talk by Mr. Bridges, Westinghouse Elec. & Mfg. Co., on the common types of Westinghouse meters. A. W. Copley commented on the development of meters. November 13. Attendance 28.

**Swarthmore College**

Election of officers. *Rectifiers*, by G. B. Hoadley, Student; and

*Power Factor Correction*, by D. C. Haskell, Student. October 18. Attendance 26.

The following papers presented by Students:

*Development of Radio Loud Speaker*, by L. E. Jewett

*Analysis of Indicator Cards*, by P. C. Smith

*Otto and Diesel Cycles*, by R. Lamey

*Transmission of Power by Belts*, by L. Rushmore

*Recent Developments in the Uses of Natural Gas*, by R. Battin. November 22. Attendance 31.

**Syracuse University**

*The Romance of High-Voltage Transmission*, by Charles W. Riley, Student. Illustrated. November 19. Attendance 9.

*Street Railway Practise*, by D. A. MacGregor, Student. November 25. Attendance 10.

*Main Line Electrification*, by Robert Fitzgerald, Student. December 2. Attendance 10

*The Klydonograph*, by O. Belayeff, Student. December 9. Attendance 20.

**University of Tennessee**

Film—"The Paths of Progress." Illustrated talk by J. F. Hazencamp, Student, on *Television*. *Report of the Senior Power Plant Survey*, by T. B. Elam, Branch Chairman. November 19. Attendance 28.

**University of Texas**

*The Life of Edison*, by Clark Blankenship, Student. Illustrated. Joint meeting with the A. S. M. E. Branch and A. S. C. E. Chapter. October 21. Attendance 100.

*Some Modern Telephone Toll Cables*, by Professor J. W. Ramsey, Electrical Engineering Dept. Illustrated. October 24. Attendance 20.

**University of Utah**

Business meeting. November 19. Attendance 13.

*The Relation of Electrical Engineering to the Telephone Industry*, by Henry W. Oddie, Transmission Engineer, Mountain States Tel. & Tel. Co. November 26. Attendance 27.

**University of Vermont**

*The History of the Incandescent Lamp*, by R. A. Daily, Student. October 15. Attendance 15.

*Sound Recording and Reproduction*, by R. H. Jeffrey, Student. Illustrated. October 29. Attendance 16.

**Virginia Military Institute**

*The Electrification of Brick Plants*, by D. B. McKenzie, Student;

*Coal Mining in Southern West Virginia*, by J. T. Walker, Student;

*Diesel Power Plants*, by W. B. Miller, Student; and

*The Application of Electricity to Lumber Industry*, by C. B. Johnson, Student. November 22. Attendance 48.

**University of Washington**

*Biography of Nikola Tesla*, by J. M. Nelson, Student. November 8. Attendance 23.

General discussion. November 15. Attendance 40.

*Where Do We Go from Here?*, by L. W. Ross, Personnel Dept., Pacific Tel. & Tel. Co. November 22. Attendance 34.

**Washington University**

*Recent Electric Developments in South America*, by S. Q. Hayes, Westinghouse Elec. & Mfg. Co. Illustrated. November 20. Attendance 39.

**West Virginia University**

The following papers were presented by Students: *Ammeters for Starting Motors*, by H. W. Unger; *Progress and Success of Electrical Engineering*, by H. O. Webb; *Influence of Temperature on Large Commutator Operation*, by D. B. Spangler; *Radio Interference Problem*, by S. B. Wolfe; *The Electric Dog*, by M. Suppa; *Electrolytic Rectifiers*, by F. E. Houck; *Effect of Magnetic Particles on Insulation*, by J. I. Steele; *Locating Rail Cancers*, by C.F. Stewart. November 18. Attendance 46.

**Worcester Polytechnic Institute**

Summer experiences reviewed by Messrs. Albert M. Goodnow, Eugene C. Center, and Allen G. Hall, Students. November 19. Attendance 19.

**Yale University**

*Relay Protection of Transmission Systems*, by R. B. Whittledge, Student. *System Planning*, by E. L. Gittleson, Student. Discussion followed. December 3. Attendance 17.

# Engineering Societies Library

*The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these founder societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.*

*In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.*

*The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.*

*The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.*

*The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August, when the hours are 9 a. m. to 5 p. m.*

## BOOK NOTICES, NOVEMBER 1-30, 1929

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

ATLAS METALLOGRAPHICUS. Lief. 3-5; Tafel 17-40.

By Hanemann & Schrader. Berlin, Gebrüder Borntraeger, 1929. 3 parts, plates, 11 x 8 in., paper portf., pt. 3, 6,60 r. m.; pts. 4 & 5, 6,75 r. m. each.

These three new sections of this useful atlas contain 143 photomicrographs of the structure of steel after various heat treatments. The photography is good and the structures are clearly shown. A clear description accompanies each plate.

BALKENBRÜCKEN.

By W. Gehler. (Handbuch für Eisenbetonbau, edited by F. Emperger. 3rd edition, v. 6, lief. 1). Berlin, Wilhelm Ernst & Sohn, 1929. 96 pp., illus., diagrs., 10 x 7 in., paper. 6,80 r. m.

This pamphlet contains the first chapter of the volume on girder bridges in Emperger's Handbuch für Eisenbetonbau; edition three. It deals with the general arrangement of these bridges, discussing the field for them and the basic forms of girders used in practise. Attention is paid to the esthetics of design. The treatment is descriptive, rather than mathematical, and numerous drawings and illustrations assist in presenting a good account of modern developments.

DIE BERECHNUNG DER KURZSCHLUSSSTRÖME VON HOCHSPANNUNGSNETZEN.

By Willi Dörbecker. Charlottenburg, Rom-Verlag, 1927. 69 pp., diagrs., 8 x 6 in., cloth. 5.-r. m.

This new method is based on a new dynamo reactance, that of the armature reaction, by use of which the author is able to eliminate all estimates and develop an accurate formula for calculating short-circuit currents. Exact results can be obtained simply and quickly, it is claimed. The method is adapted for use graphically or analytically. Results obtained by former methods are claimed to be 50 per cent too low.

BUSINESS REPORTS; Investigation and Presentation.

By Alta Gwinn Saunders and Chester Reed Anderson. N. Y., McGraw-Hill Book Co., 1929. 411 pp., 9 x 6 in., cloth. $3.50.

The first part of this book describes the steps in investigating a business; the analysis of the problem, the preparation of a plan of work, the collection and recording of the data, and its analysis and interpretation. In the second part, which is the main concern of the book, the principles of presenting information in written form are given and advice on procedure which will secure the reading of reports and acceptance of their recommendations.

LE CALCUL VECTORIEL.

By Raoul Bricard. Paris, Armand Colin, 1929. 199 pp., 7 x 5 in., paper. 10,50 fr.

A concise, clear elementary text, setting forth the principles of vector analysis and discussing the applications of the method to geometry, mechanics, and electricity.

CANALS AND INLAND WATERWAYS.

By George Cadbury and S. P. Dobbs. N. Y., Isaac Pitman & Sons, 1929. (Pitman's Transportation Library). 160 pp., illus., map, 9 x 6 in., cloth. $2.25.

A textbook for students of transportation, in which the place of the canal in a national system of transportation is defined and its competition from road and railroad discussed. Attention is given chiefly to conditions in Great Britain, but the canal systems of other European countries are also outlined briefly.

CITY PLANNING. . . . edited by John Nolen. 2d. edition. N. Y. & Lond., D. Appleton & Co., 1929. 513 pp., illus., maps, plans, 8 x 5 in., cloth. $3.50.

A carefully related series of essays by 16 authorities which, taken together, cover the essential elements of a city plan. The problems that confront practically all cities and towns are dealt with, and the best practise in investigation, planning, and control is discussed in readable form for the interested public. This edition contains new chapters on zoning and regional planning.

CONTRIBUTION A LA THÉORIE DE L'HÉLICE PROPULSIVE.

By Maurice Roy. (Aéro-Club de France. Travaux du Cercle d'Études Aérotechniques. Fascicule 3). Paris, Le Centre de Documentation Aéronautique Internationale de l'Aéro-Club de France, 1929. 38 pp., diagrs., tables, 10 x 8 in., paper.

A mathematical investigation of theories of the screw-propellor with special reference to the airscrew. Particularly the author discusses the conceptions developed by Rankine and Froude concerning the ideal screw, and points out certain modifications and corrections that are necessary.

DIE DAMPFMASCHINEN. v. 2; Bau und Betrieb der Dampfmaschinen.

By Friedrich Barth. 4th edition. Berlin, Walter de Gruyter & Co., 1929. 160 pp., illus., diagrs., 6 x 4 in., cloth. 1,50 r. m.

The second volume of this brief text deals with design and construction. The treatment is designed to the requirements of

engine-men and owners, rather than to those of designers, being largely descriptive.

Einfluss der Verunreinigungen im Sauerstoff und im Azetylen auf die Wirtschaftlichkeit und Gute des Schnittes und der Schweissnaht.

By W. Rimarski, C. Kantner and E. Streb. (Forschungsarbeiten. . . heft 317) Berlin, V. D. I. Verlag, 1929. 44 pp., illus., diagrs., tables, 12 x 9 in., paper. 6.-r. m.

Reports the methods used and the conclusions reached in an extensive laboratory investigation. Both hand and machine welding were investigated. The effect of impurities upon speed and quality was determined.

The Electromagnetic Field.

By Max Mason and Warren Weaver. Chic., University of Chicago Press, 1929. 390 pp., 10 x 7 in., cloth. $6.00.

An introduction to the mathematical field theory of electrodynamics, in which an attempt is made to keep clear the relation between the mathematical mechanism and the physical reality. The aim of the authors is to familiarize students with the Maxwell field equations in such a way that they will be prepared to evaluate without prejudice new developments in electrical theory. The book covers ground not covered by any other work in English.

Gas Analysis.

By L. M. Dennis and M. L. Nichols. Revised edition. N. Y., Macmillan Company, 1929. 499 pp., diagrs., tables, 8 x 5 in., cloth. $4.00.

Dennis' Gas Analysis has long been an accepted authority, and the new revision, the first in sixteen years, brings in the important advances during this interval. Among the new topics are methods of analysis based upon thermal conductivity, new procedures for determining specific gravity, the interferometer and its use, and a discussion of specific absorption and of the correction of barometric readings. The book covers the subject comprehensively.

Handbook of Chemistry and Physics. 14th edition.

By Charles D. Hodgman and Norbert A. Lange. Cleveland, O., Chemical Rubber Publishing Co., 1929. 1386 pp., tables, 7 x 5 in., leather. $5.00.

The new edition of this useful work has been further enlarged by data on a dozen new subjects of importance. Shrinkage conversion tables have been added to the section on ceramics, and the heats of formation and combustion of gases, coals and other organic compounds are now given, together with the physical constants of common minerals. Other new tables include the wavelengths of the principal lines of the emission spectra of the elements, the transmission of ultra violet and infra red light by various glasses, the properties of dry and saturated air, and altitude and density tables of air. The book contains a great amount of physical and chemical data frequently wanted by scientific workers.

Ions, Electrons and Ionizing Radiations.

By James Arnold Crowther. 5th edition. N. Y., Longmans, Green & Co., 1929. 253 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.

Professor Crowther has thoroughly revised his book with the aim of bringing it into harmony with current scientific thought. Some sections have been condensed, others expanded, and new sections covering important recent work have been added. The volume is intended to give students who have a knowledge of the more elementary portions of physics a systematic presentation of the latest developments.

Kompressorlose Dieselmaschinen.

By Friedrich Sass. Berlin, Julius Springer, 1929. 395 pp., illus., diagrs., 11 x 8 in., bound. 52.-r. m.

This text-book on the design of Diesel engines is based on the author's experience as director of the oil-engine division of the Allgemeine Elektricitäts-Gesellschaft, and his lectures at the Berlin Technical High School. The scientific principles involved are set forth in the opening chapters, in which fuels, ignition and combustion, the formation of mixtures, fuel injectors, fuel pumps, fuel lines and the calculation of the main dimensions are discussed. About one-half of the book is given to a thorough discussion of the working drawings of the principal elements of the engines, in much greater detail than is usual.

Die Krackverfahren unter Anwendung von Druck.

By Erwin Sedlaczek. Berlin, Julius Springer, 1929. 402 pp., illus., 9 x 6 in., cloth. 45.-r. m.

After a brief discussion of the theory of the cracking of petroleum, this book describes the 23 processes most widely used in America. On the basis of these approved methods, the author then reviews systematically the patent literature on cracking processes and apparatus. Although absolute completeness is not claimed for the book, it is a very careful compilation, which will be very useful to all those interested in cracking.

Mechanical Equipment of Buildings, v. 1; Heating and Ventilation.

By Louis Allen Harding and Arthur Cutts Willard. 2nd edition. N. Y., John Wiley & Sons, 1929. 963 pp., illus., diagrs., tables, 9 x 7 in., fabrikoid. $10.00.

Brings together the theoretical and commercial data required by the designer of heating and ventilating plants for buildings of all kinds, providing a comprehensive reference book of decided practical value. The new edition has been thoroughly revised, new material added throughout and many chapters rewritten.

Mitteilungen der Deutschen Materialprüfungsanstalten, Sonderheft 9. Kaiser Wilhelm-Institut für Metallforschung und dem Staatlichen Materialprüfungsamt zu Berlin-Dahlem. Berlin, Julius Springer, 1929. 149 pp., illus., diagrs., tables, 12 x 8 in., paper. 22,50 r. m.

The twenty reports collected in this volume discuss various structural and mechanical properties of industrial metals. The influence of lead on the structure of brass; age-hardening of silver-aluminum alloys, the influence of various metals on the properties of cast-iron, the aging of duralumin, and a variety of problems connected with metal crystals are investigated.

Photo Processes in Gaseous and Liquid Systems.

By R. O. Griffith and A. McKeown. N. Y., Longmans, Green & Co., 1929. (Textbooks of Physical Chemistry). 691 pp., diagrs., tables, 9 x 6 in., cloth. $8.50.

Intended as a textbook for senior students and research workers. The first half is devoted to those topics in modern physical theory, such as atomic and molecular structure and spectra, photoluminiscence and chemiluminescence, which are the fundamentals of photochemistry. The remainder deals with photochemical changes, their energetics, kinetics and reaction mechanisms. The book is concerned especially with the intensive research work of the past fifteen years.

Projektierung von Selektivschutzanlagen nach dem Impedanzprinzip.

By M. Walter. Charlottenburg, Rom-Verlag, 1928. 56 pp., illus., diagrs., tables, 8 x 6 in., cloth. Price not indicated.

Intended for designers and managers of high-voltage systems, this little book is a ready reference work on the design of protective installations, giving a systematic outline of the method. The method of design is outlined, the necessary formulas are explained and practical examples of design given.

Radiotechnik, v. 1; Allgemeine Einführung.

By I. Hermann. 2d edition. Berlin, Walter de Gruyter & Co., 1929. 128 pp., illus., diagrs., 6 x 4 in., cloth. 1,50 r. m.

A general introduction to radio engineering, which avoids mathematical expression as far as possible, and is intended for use by laymen, as well as students and radio men. A good general description of principles is given, but space limits forbid much detail.

Textbook of Inorganic Chemistry, edited by J. Newton Friend, vol. 6, pt. 3, Vanadium, Niobium and Tantalum. By Sydney Marks. Lond., Charles Griffin & Co., Phila., J. B. Lippincott Co., 1929. 222 pp., 9 x 6 in., cloth. $10.00.

A concise treatise on the chemistry of these elements, which aims to supply ordinary needs and to furnish adequate references to the leading works and memoirs dealing with them. One-half of the text is devoted to vanadium.

# Engineering Societies Employment Service

*Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contribution from the societies and their individual members who are directly benefited.*

*Offices:—31 West 39th St., New York, N. Y.,—W V. Brown, Manager.*
*1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.*
*57 Post St., San Francisco, Calif., N. D. Cook, Manager.*

*MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to **EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,** and should be received prior to the 15th day of of the month.*

*OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.*

*VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.*

*REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.*

### POSITIONS OPEN

ENGINEER, for utilities commission. Must be college graduate in electrical or mechanical engineering with experience in utility operation or evaluation. Apply by letter. Salary $3600-$4000 a year. Location, South. W-14.

ELECTRICAL ENGINEER, who has had broad experience in the design and development of fractional horse power a-c. and d-c. motors. Also experience in application engineering. Apply by letter giving full particulars. Location, Middle West. W-67-C.

RADIO ENGINEER, a growing research and development organization, having offices in New York City and manufacturing associations of international scope offers an excellent opportunity for a man with good theoretical training, experienced in the study of radio communication problems and the development of radio apparatus. Apply by letter giving details of experience, education and age. W-108.

ELECTRICAL ENGINEER, with experience in design and development of apparatus for wire communication. Opportunity. Apply by letter giving details of education and experience. Location, New York. W-99.

ELECTRICAL DRAFTSMAN, with some experience on substation and powerhouse layout. Opportunity. Apply by letter giving full information as to age, education, experience, when available, etc. Location, New England. X-9341.

ENGINEERS, 22-35, with considerable worthwhile radio experience for installation and servicing of talking picture equipment. Must have good personality, initiative, tact and willingness to assume responsibility. Normal hearing over entire musical scale essential and keen interest in music and quality reproduction of sound very desirable. Apply by letter. Location, Canada. W-161-C.

ELECTRICAL ENGINEER, young, as salesman of electrical instruments. Apply by letter. Location, New England. W-203.

COIL ENGINEER, ELECTRICAL ENGINEER, who is capable of heading up a general coil winding department in all its detail; namely, machinery design, coil engineering, cost and sales. Reply should state technical education, age, past experience, in fact all pertinent information. Location, Middle West. W-212.

### MEN AVAILABLE

DISTRIBUTION ENGINEER, age, 30, 10 years' varied experience in utility work, desires position as superintendent of distribution or construction in a moderate size company. Practical technical and executive ability. Desires Eastern location, New York or New Jersey preferred. C-3516.

ELECTRICAL ENGINEER, age 29, five years' varied experience; test floor, application, design, construction and maintenance. Now in charge of electrical department for mining company. Desires position as assistant plant engineer or assistant electrical engineer with large industrial plant. Good personality and very well recommended. B-9001.

ELECTRICAL ENGINEER, age 38, married. Experience, test floor, trouble shooter, sales, both correspondence and direct contact. Specialize motor, generator, control equipment. Have had charge of large repair shop. Available 30 days' notice. C-6710.

ELECTRICAL ENGINEER, 31, married, B. S. in E. E. 1923. Five years' experience with large eastern utility on aerial, underground construction standards, methods, equipment, and costs, also some statistical, appraisal, and accounting experience. One and one-half years in large industrial plant as engineering assistant to mechanical superintendent. Location, immaterial. C-6732.

ELECTRICAL ENGINEER, 30, university graduate, experienced in design of power plants and substations, economics, export, foreign languages; Spanish and German. Location, United States or abroad. Available on short notice. C-3534.

PUBLIC UTILITY EXECUTIVE, head of department of large holding company having personal jurisdiction over operation and engineering. Work includes planning for periods of five, ten years, development of power systems including steam, hydro-generation, transmission, distribution, negotiations of intercompany contracts, large power contracts, etc. Previous position, district manager of electric public utilities. C-6704.

POWER OR MECHANICAL SUPERINTENDENT, 41, experienced steam, gas, air, hydraulic, electric power plant construction and operation; institutional, industrial, and building mechanical design and maintenance. Now employed middle northwest, desires good industrial connection; 30 days' notice. Specialty, straightening out, revamping and coordinating power services. C-987.

GRADUATE ELECTRICAL ENGINEER, with strong theoretical background. Extensive practical experience in public relations, valuation, ratemaking, special economic studies, investigations and research. Well qualified as a junior executive for large industrial or public utility corporation, or director of research, special investigations or publicity. Now employed as executive. Available on reasonable notice. C-6733.

GRADUATE ELECTRICAL ENGINEER, wide experience in construction, operation, maintenace, generating transmission at 100,000 volts, underground transmission, 6600 and 22,000 volts, outdoor and in-door substations, with installations. Has had sales and managing experience Latin-America and India. Speaks English, Spanish, German, French and Hindustani. Location, immaterial. Now employed. C-4222.

DISTRIBUTION ENGINEER, B. S. Johns Hopkins 1917, M. S. University of Illinois 1925. Two years Westinghouse student and test floor, five years teaching at University of Illinois, three years distribution design with Duquesne Light Co., Pgh., Pa. Teaching, design, research, or development also considered. B-2758.

GRADUATE ELECTRICAL ENGINEER, 42, married, American, Stanford 1909, General Electric Co., Schenectady Test, power and mining engineering, sales engineering, manufacturing engineering. Five years with prominent designing and construction engineer on construction and design of hydroelectric projects, including 220-kv. transmission and the electric features of large industrial plants. Interview solicited. C-6748.

ELECTRICAL ENGINEER, 40, with 15 years' experience covering design and construction of central stations and substation equipment, negotiations, specifications, also industrial work. Desires connection with public utilities, consulting engineer or industrial organization. Excellent references. C-4533.

ELECTRICAL ENGINEER, university graduate, 36. Wide knowledge of electrification including generation, substations, distribution, motor application, control, lighting, etc., as applied to mining, cement mills, and other industries. Experience covers estimates, designs and layout, construction and maintenance. Desires to correspond with large industrial concern requiring the services of a man of above qualifications. B-9113.

GRADUATE ELECTRICAL ENGINEER, 28, married, nine years' experience, engineering, construction and operation of underground and overhead transmission and distribution systems. Last three years as division engineer for large metropolitan utility. Desires position in engineering or construction division of a large holding company or industry. Location, immaterial. B-9408.

GRADUATE, ELECTRICAL ENGINEER, 36, fifteen years' experience in design, construction and operation of hydraulic power plants in Latin

America. Four years superintendent and District Manager. Speaks fluently Spanish and French. Personality. Available short notice. Foreign countries preferred. B-8593.

ENGINEER, experienced, electrical and mechanical. Powerplant design, construction, operation, valuation. Desires connection with public utility or industrial, permanent or consulting. Specialty revamping and coordinating power services. A-782.

GRADUATE ELECTRICAL ENGINEER, specially acquainted with the selection and application of electrical equipment for power houses, substations, industrial plants, relay and meter practise, wiring diagrams, switchboard design. With operating experience. Desires position with a public utility or industrial concern. Location preferred Middle West or East. C-4696.

ELECTRICAL ENGINEER, married, graduate, 20 years' experience in design, estimating and construction of copper smelters, refineries and electrolytic plants, also familiar with concentrator and steel mill practise, many years with A. G. McGregor and Anaconda smelter. Desires responsible position as engineer, chief draftsman or in similar capacity. Available within two weeks. B-7343.

INSTRUCTOR OR ASSISTANT PROFESSOR, 28, University of Michigan, 1923, for position in one of the larger colleges. C-6756.

ENGINEER, ELECTRICAL, MECHANICAL, age 30, single, speaks and writes Russian and French. Five years' experience with European manufacturing concern. Now employed with consulting engineers corporation Desires position as assistant plant engineer or assistant electrical engineer with large industrial plant, or with consulting engineers. Available on 15 days' notice. C-5712.

TECHNICALLY TRAINED ENGINEER, with seven years' general experience with leading utility company including electrical and some gas construction, engineering, operation, maintenance, service and executive experience. Desires change to smaller property preferably south or west coast. Age 30, unmarried, and physically sound. C-6743.

ELECTRICAL ENGINEER, 30, single, graduated from University of California (1927), varied experience in power house work, research and testing as assistant engineer, also in engineering department of electrical manufacturing concern. Desires position in engineering department of public utility. Now employed on valuation. Location, preferred, New York. C-6734.

ELECTRICAL AND MECHANICAL ENGINEER, 43, married, technical university graduate, 16 years of practical experience in the design, test and operation of a-c. and d-c. motors, generators; relays, contactors and control apparatus, switchboard panels. Elevator construction, hoisting equipment and installations. Development and production work. Location, preferably East. B-5240.

ELECTROPHYSICIST, 44, five years' industrial, research, development in radio, phonographs, talkies, acoustics. Formerly professor physics and research in X-rays, positive and cathode rays, photography and electric, measuring instruments. Numerous patents, inventions, practical achievements above lines. Now with large concern, merger necessitates new connection with future. Wishes industrial position, professorship or instructorship with research. C-6467.

ELECTRICAL, MECHANICAL, REFINERY ENGINEER, 38, experienced with power station, substations, mains, motors, water and oil pumphouses, pipe lines, refinery distillation, refining, etc.; nearly 10 years with large oil company in East. Speaks Hindustani, Persian, and English. Construction and maintenance work, steam plant using coal, oil or gas disengaged. C-6785.

GRADUATE OF THE BLISS ELECTRICAL SCHOOL, class of 1927, with wide experience and good references, desires connection with contractor or industrial concern. Location, immaterial. Available any time. C-6789.

# MEMBERSHIP—Applications, Elections, Transfers, Etc.

### RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting of December 11, 1929, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

**To Grade of Fellow**

DEARBORN, RICHARD H., Head of Dept. of Electrical Engineering, Oregon State College, Corvallis, Oregon.

**To Grade of Member**

BARDWELL, HAROLD F., Research Engineer, North East Appliance Corp., Rochester, N. Y.

CRIPPEN, REID P., Assistant Electrical Engineer, Electric Bond & Share Co., New York, N. Y.

LEEVEN, ALEXANDER A., Resident Electrical Engineer, Cia Electrica Parralense, S. A., Chihuahua, Chih., Mexico.

NEUMAN, ROBERT, Local Supt., The Southern Sierras Power Co., San Bernardino, Calif.

SAHGAL, S. R., Electrical Engineer in Sind, and Assistant Electrical Engineer, Sind Electric Subdivision, P. W. D., Bombay, India.

STANLEY, JOHN L., Consulting Engineer, Hamilton, Bermuda.

WEBER, F. D., Chief Electrical Engineer, Oregon Insurance Rating Bureau, Portland, Oregon.

### APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before January 31, 1930.

Albach, C. R., American Tel. & Tel. Co, New York, N. Y.

Albright, R. H., Railway & Industrial Engineering Co., Greensburg, Pa.

Atkin, R., National Broadcasting Co., New York, N. Y.

Austin, O. C., Madison Gas & Electric Co., Madison, Wis.

Baker, D. H., Michigan Bell Telephone Co., Detroit, Mich.

Belcher, A. G., Public Service Co. of Colo., Denver, Colo.

Bitterman, D. R., Bonney Forge & Tool Works, Allentown, Pa.

Black, D. M., Bell Telephone Laboratories, New York, N. Y.

Blackmore, F. E., Westinghouse Elec. & Mfg. Co., Sharon, Pa.

Bliss, W. H., Michigan State College, East Lansing, Mich.

Block, M., Wagner Electric Corp., St Louis, Mo.

Bobun, M. J., Clark, MacMullen & Riley, New York, N. Y.

Braggins, R. M., Jr., General Railway Signal Co., Rochester, N. Y.

Brance, J. D., (Member), 1024 Post-Dispatch Bldg., Houston, Tex.

Bryant, C. F., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Budner, B. R., A. C. Electric Co., Milwaukee, Wis.

Cissna, V. J., (Member), Electric Bond & Share Co., New York, N. Y.

Conway, E. W., Chesapeake & Potomac Telephone Co., Washington, D. C.

Daily, C. F., American Tel. & Tel. Co., Cincinnati, Ohio

Davids, H. H., General Electric Co., Schenectady, N. Y.

Davis, J. A., Jr., Virginia Electric & Power Co., Norfolk, Va.

De Laura, E., Teleregister Corp., New York, N Y.

Dickinson, A. H., Mass. Institute of Technology Cambridge, Mass.

Dix, M. W., Chesapeake & Potomac Tel. Co. of West Virginia, Charleston, W. Va.

Dunn, C. V., Kansas City Power & Light Co., Kansas City, Mo.

Faulkner, E. L., Southwestern Bell Telephone Co., Houston. Tex.

Fibel, A., Brooklyn Edison Co., Brooklyn, N. Y.

Fingerman, S., Jr., U. S. Signal Corps, Oceanport, N. J.

Fisher, R. R., Wisconsin Telephone Co., Madison, Wis.

Fitzpatrick, H. H., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.

Fraser, S. C., Engineering School of Milwaukee, Milwaukee, Wis.

Friedman, T., Columbia Metal Box Co., New York, N. Y.

Gaimari, A., Electrical Engineers Equipment Co., Melrose Park, Ill.

Goodall, W. M., Bell Telephone Laboratories, Deal, N. J.

Goodridge, W. N., General Electric Co., Pittsfield, Mass.

Gradasoff, L. I., Puget Sound Power & Light Co., Bremerton, Wash.

Gray, C. J., Western Electric Co., Kearny, N. J.

Gronseth, I. H., (Member), Board of Water & Electric Light Commissioners, Lansing, Mich.

Gruner, J. E., Union Electric Lt. & Pr. Co., St. Louis, Mo.

Haile, W. B., Chesapeake & Potomac Telephone Co., Washington, D C.

Hamilton, R. M., Texas Pipe Line Co., Houston, Tex.

Hardin, W. B., Southwestern Bell Telephone Co., Houston, Tex.

Hartung, P., New York Edison Co., New York, N. Y.

Hase, R. C., Southwestern Bell Tel. Co., St. Louis, Mo.

Hatch, O. F., General Electric Co., Pittsfield, Mass.

Horan, J. F., 641 E. Market St., Danville, Pa.

Horsch, W. G., (Member), Vacuum Oil Co., Paulsboro, N. J.

Inglis, W. G., Oklahoma Gas & Electric Co., Oklahoma City, Okla.

Johnson, H. A., C. F. Henderson, San Francisco, Calif.

Joyce, J. W., Johns Hopkins University, Baltimore, Md.

Kempster, E. B., Jr., General Railway Signal Co., Rochester, N. Y.

Kilby, W. D., Public Service Electric & Gas Co., Irvington, N. J.

Knight, R. A., Pennsylvania Power Co., Greenville, Pa.

Knopf, K. K., Westinghouse Elec & Mfg. Co., Sharon, Pa.

Kramer, F. J., General Electric Co., Philadelphia, Pa.
Kremser, A. W., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
Kroll, S. A., N.Y., N.H. & H.R.R. Co., New York, N. Y.
Kuhn, J. G., Cornell University, Ithaca, N. Y.
Lack, N. M., Dielectric Products, Inc., Newport, Del.
Lawrence, J. R., Lake Shore Power Co., Wauseon, Ohio
Lee, R. E., General Electric Co., Schenectady, N. Y.
Lee, W. S., Jr., W. S. Lee Engineering Corp., Charlotte, N. C.
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| Construction of the 110-Kv. Transmission Line of the Washington Water Power Company *L. R. Gamble* | 1926 | 45 | p. 1071 |
| Notes on the Vibration of Transmission Line Conductors *T. Varney* | 1926 | 45 | p. 791 |
| Sag Calculations for Transmission Lines *H. B. Dwight* | 1926 | 45 | p. 796 |
| Recent Investigation of Transmission Line Operation *J. G. Hemstreet* | 1927 | 46 | p. 835 |
| Transmission Line Voltage Surges *J. H. Cox* | 1927 | 46 | p. 330 |
| Power Transmission and Distribution Committee Report | 1927 | 46 | p. 783 |
| Application of Relays for the Protection of Power System Inter-Connections *L. N. Crichton, H. C. Graves, Jr.* | 1928 | | p. 359 |
| Approximate Solution for Electrical Networks when These are Highly Oscillatory *E. A. Guillemin* | 1928 | | S 28-2 |
| Carrier-Current Pilot System of Transmission Line Protection *A. S. Fitzgerald* | 1928 | | p. 22 |
| Cathode Oscillograph as Used in the Study of Lightning and Other Surges on Transmission Lines *H. Norinder* | 1928 | | S 28-84 |
| Communication System of the Conowingo Development *W. B. Beals, E. B. Tuttle* | 1928 | | S 28-45 |
| Electric Oscillations in the Double-Circuit Three-Phase Transmission Line *Y. Satoh* | 1928 | | p. 58 |
| High-Voltage Oil Circuit Breakers for Transmission Networks *E. A. Crellin, Roy Wilkins* | 1928 | | p. 148 |
| Lightning Investigation on New England Power Company System *E. W. Dillard* | 1928 | | S28-100 |
| 1926 Lightning Experience on 132-Kv. Transmission Lines *P. Sporn* | 1928 | | S 29-4 |
| Oscillograph Recording Apparatus for Transmission Line Studies *J. W. Legg* | 1928 | | p. 135 |
| Power Transmission and Distribution Committee Report | 1928 | | S28-103 |
| Bessel Functions for A-C. Problems *Herbert Bristol Dwight* | 1929 | 48 | S29-112 |
| Cathode Ray Oscillograph Study of Artificial Lightning Surges on the Turners Falls Transmission Line *K. B. McEachron, V. E. Goodwin* | 1929 | 48 | S 29-51 |
| Graphic Solution of A-C. Transmission Line Problems, The *F. M. Denton* | 1929 | 48 | S 29-20 |
| System Stability as a Design Problem *R. H. Park, E. H. Bancker* | 1929 | 48 | S28-129 |
| Transmission and Distribution Committee Report | 1929 | 48 | S 29-96 |
| Movements of Overhead Line Conductors during Short Circuits *Wm. S. Peterson, H. J. McCracken, Jr.* | 1929 | 48 | S28-112 |
| **WELDING** | | | |
| Arc-Welded Structures and Bridges *A. M. Candy* | 1928 | | S 28-66 |
| Electric Welding Committee Report | 1928 | | S 28-94 |
| Electric Welding of Pipe Lines *J. D. Wright* | 1928 | | S 28-79 |
| Metallic Arc Welding Electrodes, A Study of the Effects of Surface Materials *J. B. Green* | 1928 | | S 28-16 |
| Stability of the Welding Arc *P. Alexander* | 1928 | | S 28-8 |
| Welding and Manufacturing of Large Electrical Apparatus *A. P. Wood* | 1928 | | S 28-10 |
| Rationalization of Transmission System Insulation Strength *P. Sporn* | 1928 | | S 28-67 |
| Relation between Transmission Line Insulation and Transformer Insulation *W. W. Lewis* | 1928 | | S 28-62 |
| Surge-Voltage Investigation on the 140-Kv. System of the Consumers Power Company during 1927 *J. G. Hemstreet, J. R. Eaton* | 1928 | | S 28-75 |
| Surge Voltage Investigation on the 132-Kv. Transmission Lines of the American Gas & Electric Company *P. Sporn* | 1928 | | S 28-77 |
| Surge Voltage Investigation on Transmission Lines *W. W. Lewis* | 1928 | | S 28-83 |
| Transmission Experience of the Public Service Company of Colorado *M. S. Coover, W. D. Hardaway* | 1928 | | S 28-69 |
| The Chicago Regional Power Systems *E. C. Williams* | 1928 | | p. 246 |
| Formula for Minimum Horizontal Spacing of Transmission Line Conductors as Affected by Danger of Contact in the Span *P. H. Thomas* | 1928 | | S28-101 |
| Utilization of Lodgepole Pine Timber for Poles *R. W. Lindsay* | 1928 | | S 28-90 |
| Vibration of Transmission-Line Conductors *T. Varney* | 1928 | | S 28-36 |
| Arc Welding of Steel Buildings and Bridges *Frank P. McKibben* | 1929 | 48 | S 29-57 |
| Electric Welding Committee Report | 1929 | 48 | S29-101 |

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# DIGEST OF CURRENT INDUSTRIAL NEWS

## NEW CATALOGUES AND OTHER PUBLICATIONS

*Mailed to interested readers by issuing companies*

**Distribution Transformers.**—Catalog GEA-607A, 80 pp. Describes General Electric distribution transformers. General Electric Company, Schenectady, N Y.

**Printing Press Controllers.**—Bulletin 115, 8 pp. Describes automatic magnetic reversing printing press controllers for d-c. motors. Monitor Controller Company, Baltimore, Md.

**Armature Testers.**—Bulletin, 4 pp. Describes Martindale adjustable "growlers" for testing motor armatures. Martindale Electric Company, 1260 West 4th Street, Cleveland, O.

**Capacitors.**—Bulletin GEA-77C, 20 pp. Describes General Electric capacitors for power factor correction. General Electric Company, Schenectady, N. Y.

**Bus Supports.**—Bulletin 30, 28 pp. Describes Pacific Electric outdoor bus fittings, connectors and supports. Pacific Electric Mfg. Corp., 5815 Third Street, San Francisco, Cal.

**Outdoor Switch Houses.**—Bulletin C-1861, 8 pp. Describes outdoor switch houses with oil circuit breakers. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Penna.

**Carrier Current Telephone Equipment.**—Bulletin GEA-1169, 8 pp. Describes General Electric carrier current telephone equipment, type KCA-100. General Electric Company, Schenectady, N. Y.

**Automatic Switching Equipment.**—Bulletin GEA-89B, 8 pp. Describes General Electric automatic switching equipment for outdoor a-c. reclosing feeder service, 440 to 73,000 volts. General Electric Company, Schenectady, N. Y.

**Apparatus Insulators.**—Bulletin 1858, 20 pp. Describes outdoor apparatus insulators for switchgear apparatus such as bus supports, disconnecting switches, etc. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Penna.

**Induction Voltage Regulators.**—Bulletin GEA-1030, 112 pp. Describes the design, characteristics and application of General Electric induction voltage regulators, General Electric Company, Schenectady, N. Y.

**Heat Flow Meters.**—Bulletin 4800, 12 pp. Describes Weston heat flow meters which have been developed as a result of extensive study and scientific research in Germany under the guidance of Dr. Ernest Schmidt. Weston Electrical Instrument Corporation, 584 Frelinghusen Avenue, Newark, N. J.

**Constant Speed Motors.**—Bulletin 1006-A. Describes constant speed motors in ratings from 1/30 to 1/12 horsepower, such as are used on household machines, office equipment, small pumps, control devices, signal control, etc. These motors are for both alternating and direct current. Bodine Electric Company, 2254 W. Ohio Street, Chicago, Ill.

**Recording Instruments.**—Catalog 1009, 92 pp. Describes Bristol recording gauges for pressure and vacuum. Capacities range from full vacuum to 12,000 pounds per square inch. These instruments are designed to cover practically every known requirement for vacuum and pressure of gases, steam, air and liquids. The Bristol Company, Waterbury, Conn.

**Lighting Data Bulletins.**—A series of illustrated publications describing illumination for specific applications. "Flood Lighting," bulletin LD-159, 50 pp.; "Looking Ahead in Aviation Lighting," bulletin LD-158, 58 pp.; "Electric Light on the Farm," bulletin LD-153A, 38 pp.; "Luminous Harmony in the Home," bulletin LD-137C, 34 pp. Edison Lamp Works of General Electric Company, Harrison, N. J.

**High Voltage Switches.**—Bulletin 29, 18 pp. Describes Pacific Electric type "S" switches, a development of the standard type "K" (1400) switch, pioneered in 1914. This is the original square-shaft, single rocker-insulator switch, the design of which has now been so widely adopted. The outstanding improvement in this device is the new rocker bearing and rocker shaft mounting. Pacific Electric Manufacturing Corporation, 5815 Third Street, San Francisco, Cal.

## NOTES OF THE INDUSTRY

**The Wagner Electric Corporation, St. Louis,** has removed its Chicago sales office and service station to 1935 Indiana Avenue.

**The Rockbestos Products Corporation, New Haven, Conn.,** manufacturer of asbestos insulated wires and cables, announces the appointment as sales manager of H. O. Anderson, formerly special sales engineer for the company.

**The Delta-Star Electric Company, Chicago,** announces the appointment of Paul H. Butler as manager of its New York office. For the past five years Mr. Butler has been engaged in engineering and sales work in this office of the company.

**The Locke Insulator Corporation, Baltimore, Md.,** has removed its Philadelphia office to 1405 Locust Street. J. G. Dellert, district manager, G. M. Ruoff, covering Pennsylvania and New Jersey, and W. F. Schoonmaker covering Virginia, Maryland and Delaware will have headquarters at this office.

**The Copperweld Steel Company, Glassport, Penna.,** announces the following appointments: F. A. Whitehead, formerly superintendent of rolling mills, is now general superintendent; S. L. Gibason, formerly assistant superintendent of rolling mills has become superintendent of rolling mills; J. C. Glover is now assistant superintendent of rolling mills.

**New Glass Top Fuse Plugs.**—The General Electric Company has introduced a new type of fuse plug, with a "Pyrex" glass top shaped as a lens, which insures clear vision and magnifies the fuse strip. Since this fuse plug has a non-metallic insulated top, there are no exposed metal parts when it is inserted in a cutout. The new G. E. fuse plug has an added safety feature in that the "Pyrex" glass top is tough and does not shatter. The link is enclosed in a deep porcelain cup in which the arc is ruptured.

**Improved Cell Type Capacitors.**—The Electric Machinery Manufacturing Company of Minneapolis, Minn., has recently announced a new improved line of cell type capacitors for use in power factor improvement. These capacitors are built for either indoor or outdoor use, the outdoor type capacitor being completely enclosed in a sheet steel housing. The E-M capacitor consists of an assembly of capacitor cells securely mounted on a rugged steel stand. Each cell is a complete capacitor unit, and by connecting two or more cells in parallel, any desired kv-a. may be obtained.

**1930 Program for New York Power Companies.**—The New York Edison Company and associated electric light and power companies serving Manhattan, Bronx, Brooklyn, Queens and Yonkers will in 1930 spend $76,848,053 for construction purposes, according to Matthew S. Sloan, president of these companies. In 1929 about $80,000,000 was spent. The budget covers both supplies and labor, and wages represent a substantial portion of the total. The principal items are as follows: Generating Stations, $20,581,095; Substations, $1,204,008; Buildings and Yards, $2,458,000; Transmission and Distribution, $50,250,950; Miscellaneous, $2,354,000, of which transportation equipment will take $1,000,000.

**New Laboratory for Westinghouse.**—An expenditure of $1,500,000 will be made by the Westinghouse Electric and Manufacturing Company in the construction of a central engineering laboratory and an addition to the present direct current power laboratory, both in East Pittsburgh. Test circuits of almost any voltage and frequency will be provided for. The new laboratory will eventually replace numerous smaller laboratories and experimental test sections now scattered throughout the plant. Work has already started on the laboratory, an eleven-story structure 80 feet wide and 225 feet long. Adjacent to this building will be the 125-foot extension to the direct current laboratory.